The Low-Mass Companion to the Lithium-Depleted, Spectroscopic Binary HBC 425 (St 34)

S. E. Dahm and J. E. Lyke

W. M. Keck Observatory, Kamuela, HI 96743

Received 2011 June 1; accepted 2011 November 7; published 2011 November 23

ABSTRACT. We present high angular resolution, near-infrared imaging, and spectroscopy of a low-mass companion to the lithium-depleted, double-line spectroscopic binary HBC 425 (St 34) obtained using NIRSPEC and the Keck II adaptive optics system. Positioned ∼1.23″ southeast of the primary pair, the companion, HBC 425C, is ∼2.4 mag fainter at 2.2 μm. Moderate-resolution (R ∼ 2500) J- and K-band spectroscopy reveals HBC 425C to have an M5.5 (±0.5) spectral type. Comparisons with pre-main-sequence evolutionary models imply a mass of ∼0.09 M⊙ and ages of 8–10 Myr, assuming the nominal distance of Taurus-Auriga (∼140 pc), or ∼25 Myr if placed at ∼90 pc. We also present high-dispersion optical spectra of HBC 425 and HBC 425C obtained using the high-resolution echelle spectrometer (HIRES) on Keck I. We detect strong Li I λ6708 absorption in the spectrum of HBC 425C. Using curves of growth for the Li I λ6708 doublet, we estimate its abundance level to lie between log N(Li) = 1.9 and 3.1 dex. The spectrum of HBC 425 exhibits Ca II H and K lines, He I λ5876, 6678, and strong Balmer line emission, consistent with accretion. We place more restrictive upper limits on the surface abundance of lithium and find that HBC 425 retains less than ∼0.1% of its primordial abundance. The presence of lithium in the photosphere of HBC 425C does not resolve the discrepancy between isochronal and lithium-depletion ages for the primary pair. However, if lithium were depleted relative to interstellar abundance levels, even minimally, considerable support would be gained for the more advanced age of this hierarchical triple system.

Online material: color figures

1. INTRODUCTION

Low-mass (M ≤ 1 M⊙), pre-main-sequence stars are fully convective as they gravitationally contract and descend their vertical tracks in the color-magnitude diagram (Hayashi 1961). When core temperatures reach 2.5 to 3.0 MK, lithium depletion begins as its dominant isotope (7Li) fuses with hydrogen nuclei to form 3He (Bodenheimer 1965). Convective processes circulate material through the stellar core, depleting all available lithium over timescales of tens of millions of years (Baraffe et al. 1998; Song et al. 2002, and references therein). In spite of its low abundance, 7Li is readily observed in stellar atmospheres in an electronic transition that is a strong doublet at λ6707.78, 6707.93. Given the short timescale of lithium depletion, the presence of Li I λ6708 absorption in the spectra of low-mass stars is recognized as an indicator of youth (e.g., Bonsack & Greenstein 1960; Herbig 1965). Stars presumably begin their lives with an amount of lithium consistent with interstellar abundance levels. Anders & Grevesse (1989) derive an abundance of lithium extracted from carbonaceous chondrites of N(Li) = 3.31 ± 0.04 dex, which is adopted here as the interstellar 7Li abundance level.

HBC 425 (St 34) was first identified as an Hα emission star in the objective prism survey of Stephenson (1986). The star was classified by Downes & Keyes (1988) as an early- to mid-M-type star exhibiting Balmer line and He I λ5876 emission. The spectral type was further refined to M3 by White & Hillenbrand (2005), who determined that HBC 425 is a double-line spectroscopic binary with components of identical effective temperature and luminosity. HBC 425 lies ∼1.5° from the molecular cloud core L1558 near the southern extremity of the Taurus-Auriga molecular cloud complex and was subsequently assumed to be a member of the star-forming region, given its strong T Tauri-like attributes.

Surprisingly, White & Hillenbrand (2005) discovered that neither component of the double-line spectroscopic binary exhibits Li I λ6708 absorption. The isochronal age of HBC 425 was determined to be 8 ± 3 Myr, substantially younger than the predicted lithium-depletion timescale of ∼25 Myr using the pre-main-sequence models of Baraffe et al. (1998). White & Hillenbrand (2005) suggested that a distance of ∼90 pc would reconcile the discrepancy between isochronal and lithium-depletion ages at ∼21–25 Myr. Hartmann et al. (2005) favor this interpretation, making HBC 425 the oldest known accreting pre-main-sequence star. Given such strong evidence for membership in Taurus-Auriga, however, White & Hillenbrand (2005) conclude that HBC 425 is likely much younger than is implied by the lithium depletion.

1383
Hartmann et al. (2005) obtained a mid-infrared spectrum of HBC 425 using the infrared spectrograph on Spitzer (Werner et al. 2004). The spectrum revealed substantial excess emission at wavelengths greater than 5.4 $\mu$m, but the lack of excess emission at shorter wavelengths (i.e., 2.2 $\mu$m) implied the presence of an evacuated inner-disk region. The depleted inner disk would likely result from dynamical clearing by the two components of the spectroscopic binary, similar to the CoKu Tau 4 system that was previously recognized as a transition disk. The depleted inner disk is associated with accretion or chromospheric activity: CaII H and K, as well as permitted and forbidden transitions that are generally gravity- and temperature-sensitive photospheric features, as suggested by Baraffe et al. (1998) to reevaluate the mass and age of the HBC 425 system. We also present high-dispersion optical spectra of HBC 425 and HBC 425C and use these spectra to examine the kinematics of the system and to place limits on the abundance of lithium present in their photospheres.

2. OBSERVATIONS

2.1. Adaptive Optics Near-Infrared Imaging and Spectroscopy

NIRSPEC (McLean et al. 1998), installed behind the adaptive optics system of Keck II (NIRSPAO), was used on 2010 December 12 to obtain moderate-dispersion ($R \sim 2500$) J- and K-band spectra of HBC 425 and HBC 425C. This component was first noted by White & Hillenbrand (2005), who estimated it to be $\sim 2.5$ mag fainter than the primary in the $K$ band. We use the pre-main-sequence models of Baraffe et al. (1998) to reevaluate the mass and age of the HBC 425 system. We also present high-dispersion optical spectra of HBC 425 and HBC 425C and use these spectra to examine the kinematics of the system and to place limits on the abundance of lithium present in their photospheres.

The kinematic survey of Taurus-Auriga by Bertout & Genova (2006) found insignificant proper motions for HBC 425, as well as for 10 other assumed Taurus-Auriga members, including CoKu Tau 4, DQ Tau, and V836 Tau. While purely circumstantial in nature, the lack of significant proper motion may argue in favor of a larger distance estimate for HBC 425, i.e., more consistent with the distance of Taurus-Auriga.

In this work we present near-infrared adaptive optics imaging and spectroscopy of HBC 425C, an apparent low-mass companion positioned $\sim 1.29''$ southeast of the spectroscopic binary. The stars were nodded along the slit and observed in three positions to ensure proper sky subtraction. Aperture photometry was performed on HBC 425 and HBC 425C using the phot task in the DAOPHOT package of IRAF on sky-subtracted images. An aperture radius of 10 pixels (0.168") was adopted for the analysis. Photometric uncertainties are represented by the standard deviation of measurements on several sky-subtracted frames in each filter. Absolute photometric calibration was achieved by using the Two Micron All Sky Survey (2MASS) $J$-, $H$-, and $K_S$-band magnitudes for HBC 425. Photometry for these sources is presented in Table 1.

2.2. High-Dispersion Optical Spectroscopy

The high-resolution echelle spectrometer (HIRES) is a grating cross-dispersed spectrograph permanently mounted on the Nasmyth platform of Keck I (Vogt et al. 1994). High-dispersion spectra were obtained using HIRES with the red cross-disperser and collimator in beam on the nights of 2010 December 2, 2011 October 12, and 2011 October 19 (UT), abbreviated henceforth as J2010, J2011A, and J2011B, respectively. All nights were photometric, with seeing conditions of $\sim 0.85''$ for J2010 and J2011B and $\sim 0.60''$ for J2011A. The B2 decker (0.574" $\times$ 7") was used during J2010 to provide a spectral resolution of $\sim 66,000$ ($\sim 4.5$ km s$^{-1}$). Nearly complete wavelength coverage from $\sim 3650$–7900 $\AA$ was achieved, a region that includes many gravity- and temperature-sensitive photospheric features, as well as permitted and forbidden transitions that are generally associated with accretion or chromospheric activity: Ca II H and K lines, H$\gamma$, H$\beta$, He I $\lambda 5876$, [O I] $\lambda 6300$, and H$\alpha$. For the J2011 observations, the cross-disperser angle was altered to provide expanded wavelength coverage in the red, from $\sim 3800$ to $\sim 8500$ $\AA$.

| Source | J  | H  | K$_S$ |
|--------|----|----|-------|
| HBC 425 | 11.44 ± 0.02 | 10.83 ± 0.02 | 10.54 ± 0.02 |
| HBC 425C | 13.17 ± 0.08 | 12.61 ± 0.06 | 12.23 ± 0.03 |

* The 2MASS photometry for HBC 425 is corrected for the equally luminous spectroscopic binary companion.

* Magnitudes for HBC 425C are calibrated using the 2MASS photometry for HBC 425.
spectra were obtained for wavelength calibration. Several radial- and rotational-velocity standard stars having M0–M3.5 spectral types from Nidever et al. (2002) and Browning et al. (2010) were observed during the nights. The HIRES observations were reduced using the Mauna Kea Echelle Extraction, makee, reduction script, which is publicly available through links on the HIRES Web site.

3. HBC 425: THE SPECTROSCOPIC BINARY

The heliocentric radial velocities of the individual components of HBC 425 were determined by cross-correlation analysis using the M0.5-type radial-velocity standard HD 28343 as a template. To distinguish primary from secondary, we assume that the depths of absorption lines are greater for the former than for the latter, implying a slight difference in spectral type. The J2010 HIRES spectrum of HBC 425 was obtained when the velocities of the two components were nearly reversed from those reported by White & Hillenbrand (2005), −10.67 and +46.32 km s$^{-1}$ for the primary and secondary, respectively. The J2011A HIRES spectrum reveals singlecomponent absorption-line profiles, implying equal velocities of $\sim +16.8$ km s$^{-1}$. The J2011B radial velocities were measured to be +41.42 and −5.53 km s$^{-1}$ for the primary and secondary, respectively.

\begin{table}
\centering
\caption{Observed Properties of HBC 425 and HBC 425C}
\begin{tabular}{lcccc}
\hline
Parameter & System & Primary & Secondary & HBC 425C \\
\hline
W(Ca K line) (Å) & ... & −1.72 & −2.37 & ... \\
W(Hα) (Å) & ... & −6.43 & ... & ... \\
W(Hγ) (Å) & ... & −8.96 & ... & ... \\
W(Hδ) (Å) & ... & −27.35 & ... & ... \\
Hα 10% width (km s$^{-1}$) & ... & 366 & ... & ... \\
W(Li i) (Å) & ... & ≤0.03 & ≤0.03 & ... \\
Radial velocity (km s$^{-1}$) & ... & +17.89 & −10.67 & +46.32 \\
\hline
\end{tabular}
\end{table}

\begin{table}
\centering
\caption{Inferred Properties for HBC 425 and HBC 425C}
\begin{tabular}{lccc}
\hline
Parameter & HBC 425 A+B & HBC 425C \\
\hline
Mass ($M_\odot$) & 0.35 & 0.09 \\
$T_{\text{eff}}$ (K) & 3415 & 3058 \\
Spectral type & M3 & M5.5 \\
log $L/L_\odot$$^a$ & −1.07 & −1.82 \\
Mass ratio ($q$) & 1.00 & ... \\
Semimajor axis (AU) & <0.2 & 172$^b$ \\
Period (days) & <54 & ... \\
\hline
\end{tabular}
\end{table}

$^a$ Assumes $d = 140$ pc, consistent with Taurus-Auriga.

$^b$ Projected separation assuming $d = 140$ pc.
Lacking sufficient observations for a complete orbit determination, we use the method of Wilson (1941) to derive the mass ratio \(q\) and systemic velocity \(\gamma\) of the system defined by

\[
q = \frac{v_2 - u_1}{u_1 - u_2},
\]

and

\[
\gamma = \frac{u_1 v_2 - u_2 v_1}{(v_2 - v_1) - (u_2 - u_1)},
\]

where \(u_1\) and \(u_2\) are the J2010 and J2011B velocities of the primary, and \(v_1\) and \(v_2\) are those of the secondary. We find \(q = 1.00\) and \(\gamma = 17.89\) km s\(^{-1}\). This systemic velocity is consistent with that derived by White & Hillenbrand (2005) and with the radial velocities of known Taurus-Auriga members.

Adopting the masses for the primary and secondary derived by White & Hillenbrand (2005), 0.37 \(M_\odot\), and assuming circular orbits with an inclination angle of 90\(^\circ\), an upper limit for the semimajor axis of the system is \(\sim 0.2\) AU. An upper limit for the period of the spectroscopic binary follows, \(\sim 0.15\) yr or \(\sim 54\) days. It is likely, however, that these observations and that of White & Hillenbrand (2005) were not made at maximum velocity separation and that the system is not observed edge-on.
The HIRES spectra of HBC 425 reveal strong, broad H\(\alpha\) emission with \(W(H\alpha) = -27.4\) Å (J2010), \(-40.0\) Å (J2011A), and \(-36.8\) Å (J2011B). Taken together with the equivalent widths reported by White & Hillenbrand (2005), \(W(H\alpha) = -51.6\) Å and Downes & Keyes (1988), \(-78\) Å, these measurements imply significant variability. The J2010 and J2011 H\(\alpha\) emission profiles are double-peaked and similar in appearance, with velocity widths of \(~366\) km s\(^{-1}\) (J2010), \(462\) km s\(^{-1}\) (J2011A), and \(468\) km s\(^{-1}\) (J2011B), indicative of accretion using the H\(\alpha\) 10% width of peak emission criterion of White & Basri (2003). Higher-order Balmer transitions (H\(\beta\), H\(\gamma\), H\(\delta\), and H\(\epsilon\)) are also double-peaked, but with smaller-velocity separations. Broad, blue-shifted wings are evident in these emission lines, suggestive of accretion-driven winds. [O I] \(\lambda\)6300 is also found in emission, with radial velocities of \(+10.6\) km s\(^{-1}\) (J2010), \(+18.1\) km s\(^{-1}\) (J2011A), and \(+20.2\) km s\(^{-1}\) (J2011B). The uncertainties for these velocities are \(\pm 2\) km s\(^{-1}\). Such forbidden emission may arise from a circumbinary disk wind, given its nearly systemic velocity (e.g., Hartigan et al. 1995). There is no evidence of [S II] \(\lambda\lambda 6717, 6730\) emission in the HIRES spectra.

The Ca II H and K lines (J2010) are double-peaked, but while strongly in emission the features are narrow and lack the broadened wings evident in the Balmer lines. These Ca II emission peaks are consistent with the velocities of the primary and secondary, implying that they arise from chromospheric activity associated with each component. The Na I D lines (J2010) exhibit central absorption flanked by emission peaks that also correlate with the velocities of the primary and secondary. The strength of these chromospheric emission lines (i.e., Ca II and Na I) is greater in the secondary than in the primary. The Ca II near-infrared triplet (\(\lambda\lambda\lambda 8498, 8542, 8662\)) was included in the J2011 spectra. These features exhibit emission reversal that nearly fills the wings of the underlying absorption profiles. The radial velocities of the double emission lines present in the Ca II near-infrared triplet in the J2011B spectrum again correlate with the velocities of the primary and secondary. Shown in Figure 1 are sections of the J2010, J2011A, and J2011B HIRES spectra, including Ca II K line, Ca II \(\lambda\lambda 8542, Ca I \lambda\lambda 6102.72\) (exemplifying the double-lined features observed in the J2010 and J2011B spectra), and H\(\alpha\).

Lithium is clearly depleted in both components of the spectroscopic binary. Shown in Figure 2 is an expanded region of one order of the J2010 spectrum centered near Li i \(\lambda\)6708. The spectrum of the M3-type main-sequence star Gl 806 is shown for comparison. Although weak absorption features appear at the wavelengths expected for the primary and secondary, the
strengths of these features are consistent with the level of variation observed in the pseudocontinuum of the star. The measured equivalent widths, ∼30 mA, serve as upper limits that are a factor of 2 lower than that determined by White & Hillenbrand (2005). Using the curves of growth for the Li I λ6708 transition derived by Pavlenko & Magazzu (1996) and adopting an effective temperature of 3500 K with log g = 4.5, we determine an upper limit for the surface Li I abundance in HBC 425 to be between log N(Li) = −0.5 and −1.0 dex. From this we infer that lithium is depleted in the photospheres of HBC 425A + B by at least ∼3 orders of magnitude relative to interstellar abundance levels.

4. HBC 425C: THE LATE-TYPE WIDE BINARY COMPANION

HIRES guide camera images (Figure 3a) revealed the presence of a tertiary component of HBC 425. White & Hillenbrand (2005) noted this companion and estimated it to be ∼2.5 mag fainter than the primary in the K band. The companion is separated by ∼1.23", corresponding to a projected separation of ∼172 AU, assuming the traditionally accepted distance of Taurus-Auriga, (∼140 ± 10 pc: Kenyon et al. 1994). To estimate the probability of a chance alignment, we follow the example of Metchev & Hillenbrand (2009) and sum the number of sources within a 5' radius of HBC 425 in the 2MASS point source catalog. Multiplying this value by the ratio of solid angles, (1.23")2/(5')2, we derive a probability for a purely geometric alignment of ∼0.2%. The radial velocity of HBC 425C is also measured to be +15.9 km s⁻¹, consistent with the systemic velocity of HBC 425.

Shown in Figure 3b is a background-subtracted NIRSPAO H-band image of HBC 425 and HBC 425C obtained using SCAM. The sources are clearly separated, allowing the slit to be aligned along the axis of the binary without concern for overlapping point-spread functions. Shown in Figures 4 and 5 are the extracted J- and K-band spectra, respectively, for HBC 425 and HBC 425C, with critical atomic and molecular features identified. Superposed and plotted with additive constants are spectra for standard stars (M3–M8 types) obtained from the Infrared Telescope Facility (IRTF) spectral library (Cushing et al. 2005; Rayner et al. 2009). Weak Paβ and Brγ emission are observed in the spectra of HBC 425, consistent with accretion activity. The strength of atomic lines and molecular features in the spectra of HBC 425 support the M3 classification of White & Hillenbrand (2005).

The J- and K-band spectra of HBC 425C and its near-infrared colors are consistent with a M5.5 ± 0.5 spectral type. The lack of strong Ca I absorption near 2.26 μm is suggestive of being later than M5. Although the J-band spectrum is affected by the lower throughput of the N3 filter at shorter wavelengths, the K I doublet near 1.17 μm is clearly stronger in HBC 425C than in HBC 425 and is suggestive of ≥M5 spectral type. There is no evidence for Paβ or Brγ emission in the spectrum of HBC 425C, implying that this source is either not accreting or is accreting at levels below the detection threshold for these diagnostics. The near-infrared colors of HBC 425C are also consistent with purely photospheric emission. It is evident from weak J-H excesses that both HBC 425 and HBC 425C suffer minimal foreground extinction.

The HIRES spectrum of HBC 425C reveals strong Li I λ6708 absorption. Shown in Figure 2 are the spectra of HBC 425C and UX Tau C, an M5-type Taurus-Auriga member, centered near λ6708. The measured equivalent width of Li I λ6708, W(Li), for HBC 425C is ∼0.32 ± 0.05 Å, substantially lower than that of UX Tau C, W(Li) = 0.6 Å. This is, in part, due to scattered light from HBC 425 that artificially elevates the observed continuum level. To estimate the level of scattered-light contamination, we use the slit guide camera.
to interstellar levels, we cannot conclusively demonstrate this that the abundance of lithium in HBC 425C is depleted relative of the cosmic or primordial abundance level. While it is possible assumed by Zapatero Osorio et al. (2002) to be representative lar levels. Correcting \( W(Li) \) for the scattered-light contribution near \( \lambda \) photometry for HBC 425C in the original image, we find that the C5 decker centered on HBC 425C. Performing aperture the flux in a circular aperture equivalent in size to the width of point-spread function of HBC 425 from the image and measure to construct a model point-spread function, we remove the region of significant lithium depletion, while the onset of depletion should be occurring in HBC 425C.

Images of the HBC 425 system taken through the RG610 photometric filter. Using the nearby field star J04542362 + 1709434 to construct a model point-spread function, we remove the point-spread function of HBC 425 from the image and measure the flux in a circular aperture equivalent in size to the width of the C5 decker centered on HBC 425C. Performing aperture photometry for HBC 425C in the original image, we find that \( \sim 20-40\% \) of the incident light likely originates from HBC 425. Removing this scattered-light contribution from the continuum near \( \lambda 6700 \) in the HIRES spectrum of HBC 425C, we measure \( W(Li) = 0.47_{-0.06}^{+0.08} \) Å. Using the LTE curves of growth for the Li i \( \lambda 6708 \) transition from Zapatero Osorio et al. (2002) and assuming an effective temperature consistent with HBC 425C (2900–3100 K), we find that the measured equivalent width, \( W(Li) \sim 0.32 \) Å, implies a lithium abundance of \( log N(Li) \sim 1.6 \) dex, suggestive of substantial depletion relative to interstellar levels. Correcting \( W(Li) \) for the scattered-light contribution from HBC 425, we estimate the lithium abundance level to be between \( log N(Li) \sim 1.9 \) and 3.1 dex, where the latter is assumed by Zapatero Osorio et al. (2002) to be representative of the cosmic or primordial abundance level. While it is possible that the abundance of lithium in HBC 425C is depleted relative to interstellar levels, we cannot conclusively demonstrate this with the present seeing limited observations.

5. DISCUSSION AND CONCLUSIONS

Binaries play a crucial role in assessing the accuracy of pre–main-sequence evolutionary models and isochrones (e.g., Hillenbrand & White 2004; Mathieu et al. 2007). Using the effective temperature scale of Luhman et al. (2003), extinction-corrected \( J \)-band magnitudes, and the main-sequence bolometric corrections of Kenyon & Hartmann (1995), we place HBC 425A, HBC 425B, and HBC 425C on the Hertzsprung-Russell (HR) diagram shown in Figure 6a. Superimposed are the 1, 3, 10, and 20 Myr and 1 Gyr isochrones, as well as the 0.35, 0.1, and 0.08 \( M_\odot \) evolutionary tracks of Baraffe et al. (1998), placed at the nominal distance of Taurus-Auriga ~140 pc. The solar metallicity Baraffe et al. (1998) models incorporate nongray atmospheres and assume a general mixing-length parameter given by \( \alpha = 1 \). Each component of HBC 425 falls near the 0.35 \( M_\odot \) evolutionary track at an age of \( \sim 10 \) Myr. HBC 425C lies near the 0.09 \( M_\odot \) evolutionary track with a coeval age of \( \sim 8-10 \) Myr.

Also depicted in Figure 6a are the theoretical lithium-depletion curves of Chabrier & Baraffe (1997). The onset of depletion is represented by the enhanced dashed curve, and the crosshatched region represents significant depletion of \( \sim 3 \) orders of magnitude or greater from initial abundance levels. The models predict that HBC 425 should have experienced some degree of lithium depletion at its assumed age of \( \sim 10 \) Myr, while HBC 425C should still retain its primordial lithium abundance. As originally noted by White & Hillenbrand (2005), if a member of Taurus-Auriga, the level of lithium depletion observed in HBC 425 is clearly inconsistent with the models of Chabrier & Baraffe (1997). White & Hillenbrand (2005) summarize three possible explanations:

1. The effective temperature of HBC 425 is \( \sim 340 \) K hotter than anticipated for its M3 spectral type.
2. HBC 425 lies in the foreground of Taurus-Auriga by some \( \sim 50 \) pc and is consequently much older than previously assumed.
3. A problem exists in models of lithium depletion for low-mass pre–main-sequence stars. We can only address the second of these hypotheses with the observations presented here.

Also shown in Figure 6b is the HR diagram of the HBC 425 system placed at a distance of 90 pc. The ages of HBC 425 and HBC 425C are coeval near \( \sim 25 \) Myr. From their placement relative to the region of significant lithium depletion, both components of the spectroscopic binary should have experienced nearly complete lithium destruction, as observed. The substantially-lower-mass HBC 425C, however, lies on or near the boundary, representing the onset of lithium depletion. If shown to be lithium-depleted relative to interstellar abundance levels, even minimally, this would greatly strengthen the argument for the more advanced age (\( \sim 25 \) Myr) and the more proximal distance (\( \sim 90 \) pc) to the system.
The presence of mid-infrared excess indicative of a primordial disk around HBC 425 (Hartmann et al. 2005), as well as strong Hα emission, consistent with accretion (White & Hillenbrand 2005 and this investigation) complicates this issue considerably. The timescale of disk dissipation within the terrestrial region has been reasonably well established by ground-based observations (e.g., Haisch et al. 2001; Mamajek et al. 2004) and Spitzer observations (e.g., Uchida et al. 2004; Silverstone et al. 2006) to be ≤10 Myr. The existence of an accretion disk having an age ~2.5 times this limit, while certainly not beyond reason, is exceptional nonetheless. The question of lithium depletion in HBC 425 remains unresolved. It is not without precedent, however: e.g., HIP 112312A in the ~12 Myr old β Pictoris moving group (Song et al. 2002). While the lithium-depletion age of HIP 112312A is ~35 Myr, its isochronal age is ~6 Myr. High-precision proper motions of HBC 425 that could unambiguously determine its membership status in Taurus-Auriga are needed. Clearly, a dedicated effort must be made to determine the distance to this enigmatic system and thereby resolve the lithium-depletion problem.

The digitized sky surveys, which were produced at the Space Telescope Science Institute under US Government grant NAG W-2166, were used, as were the SIMBAD database operated at CDS, Strasbourg, France, and the Two Micron All Sky Survey (2MASS), a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center (IPAC)/California Institute of Technology, funded by NASA and the National Science Foundation. S. E. D. is grateful to Russel White, Lynne Hillenbrand, and G. H. Herbig for insightful discussions regarding the nature of HBC 425 and to an anonymous referee whose comments and suggestions greatly improved this article. S. E. D. is also grateful to the Director of W. M. Keck Observatory for the use of the Director’s time in carrying out this program and to Heather Hershley and Terry Stickel for their dedicated efforts in supporting these observations.

REFERENCES

Anders, E., & Grevesse, N. 1989, Geochim. Cosmochim. Acta, 53, 197
Andrews, S. M., & Williams, J. P. 2005, ApJ, 631, 1134
Baraffe, I., Chabrier, G., Allard, F., & Hauschildt, P. H. 1998, A&A, 337, 403
Bertout, C., & Genova, F. 2006, A&A, 460, 499
Bodenheimer, P. 1965, ApJ, 142, 451
Bonsack, W. K., & Greenstein, J. L. 1960, ApJ, 131, 83
Browning, M. K., Basri, G., Marcy, G. W., West, A. A., & Zhang, J. 2010, AJ, 139, 504
Chabrier, G., & Baraffe, I. 1997, A&A, 327, 1039
Cushing, M. C., Rayner, J. T., & Vacca, W. D. 2005, ApJ, 623, 1115
Downes, R. A., & Keyes, C. D. 1988, AJ, 96, 777
Haisch, K. E., Jr., Lada, E. A., & Lada, C. J. 2001, ApJ, 553, L153
Hartigan, P., Edwards, S., & Ghandour, L. 1995, ApJ, 452, 736
Hartmann, L., et al. 2005, ApJ, 628, L147
Hayashi, C. 1961, PASJ, 13, 450
Herbig, G. H. 1965, ApJ, 141, 588
Hillenbrand, L. A., & White, R. J. 2004, ApJ, 604, 741
Ireland, M. J., & Kraus, A. L. 2008, ApJ, 678, L59
Kenyon, S. J., Dobrzycka, D., & Hartmann, L. 1994, AJ, 108, 1872
Kenyon, S. J., & Hartmann, L. 1995, ApJS, 101, 117
Luhman, K. L., Stauffer, J. R., & Muench, A. A., et al. 2003, ApJ, 593, 1093
Mamajek, E. E., Meyer, M. R., & Hinz, P. M., et al. 2004, ApJ, 612, 496
Mathieu, R. D., Baraffe, I., Simon, M., Stassun, K. G., & White, R. 2007, in Protostars and Planets V (Tucson: Univ. Arizona Press), 411
McLean, I. S., Becklin, E. E., & Bendiksen, O., et al. 1998, Proc. SPIE, 3354, 566
Metchev, S. A., & Hillenbrand, L. A. 2009, ApJS, 181, 62
Nidever, D. L., Marcy, G. W., Butler, R. P., Fischer, D. A., & Vogt, S. S. 2002, ApJS, 141, 503
Pavlenko, Y. V., & Magazzu, A. 1996, A&A, 311, 961
Rayner, J. T., Cushing, M. C., & Vacca, W. D. 2009, ApJS, 185, 289
Silverstone, M. D., Meyer, M. R., & Mamajek, E. E., et al. 2006, ApJ, 639, 1138
Song, I., Bessell, M. S., & Zuckerman, B. 2002, ApJ, 581, L43
Stephenson, C. B. 1986, ApJ, 300, 779
Uchida, K. I., Calvet, N., & Hartmann, L., et al. 2004, ApJS, 154, 439
Vogt, S. S., et al. 1994, Proc. SPIE, 2198, 362
Werner, M. W., et al. 2004, ApJS, 154, 1
White, R. J., & Basri, G. 2003, ApJ, 582, 1109
White, R. J., & Hillenbrand, L. A. 2005, ApJ, 621, L65
Wilson, O. C. 1941, ApJ, 93, 29
Zapatero Osorio, M. R., Béjar, V. J. S., & Pavlenko, Y., et al. 2002, A&A, 384, 937

1390 DAHM & LYKE