SPECTROSCOPY OF CANDIDATE MEMBERS OF THE η CHAMELEONTIS AND MBM 12 YOUNG ASSOCIATIONS

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ABSTRACT

We present an analysis of candidate members of the η Cha and MBM 12A young associations. For an area of 0.7 deg² toward η Cha, we have performed a search for members of the association by combining JHK_s photometry from the Two Micron All Sky Survey and i photometry from DENIS with follow-up optical spectroscopy at Magellan Observatory. We report the discovery of three new members with spectral types of M5.25–M5.75, corresponding to masses of 0.13–0.08 M_⊙ by theoretical evolutionary models. Two and three of these members were found independently by Lyo and coworkers and Song and coworkers, respectively. Meanwhile, no brown dwarfs were detected in η Cha down to the completeness limit of 0.015 M_⊙. For MBM 12A, we have obtained spectra of three of the remaining candidate members that lacked spectroscopy at the end of the survey by Luhman, all of which are found to be field M dwarfs. Ogura and coworkers have recently presented four “probable” members of MBM 12A. However, two of these objects were previously classified as field dwarfs by the spectroscopy of Luhman. In this work, we find that the other two objects are field dwarfs as well.

Subject headings: infrared: stars — stars: emission-line, Be — stars: evolution — stars: formation — stars: low-mass, brown dwarfs — stars: pre–main-sequence

1 INTRODUCTION

The environs of the B8 star η Cha and the dark cloud MBM 12 have been revealed as sites of small associations of newly formed stars. Through deep ROSAT observations of 0.35 deg² toward η Cha, Mamajek et al. (1999) discovered X-ray emission detected with slitless data from 2MASS (Cha and MBM 12 associations. For MBM 12A, we select candidate members from Luhman (2001) and Ogura et al. (2003) have since identified four “probable” members of MBM 12A via Hα emission detected with slitless grism spectroscopy.

In this paper we present spectroscopy of candidate members of the η Cha and MBM 12 associations. For η Cha we select candidate members of the association by combining i photometry from DENIS and JHK_s data from 2MASS we obtain follow-up spectroscopy to distinguish between field stars and bona fide members. For our survey of η Cha, we...
utilized $i$ photometry from the DENIS Second Release and $JHK_s$ photometry from the 2MASS Point Source Catalog. These surveys exhibit a signal-to-noise ratio of 10 at $i/C_{24}^{17}$, $J/C_{24}^{15}$: 8, $H/C_{24}^{15}$: 1, and $K_s/C_{24}^{14}$: 3. We considered all sources appearing in both databases within a radius of 0.25$^\circ$ from the center $\alpha = 8^h42^m30^s$, $\delta = -78^\circ58'00''$ (J2000.0). The size of this survey field was selected to extend well beyond the positions of the known members of the association. Two areas within this radius were not available from the DENIS Second Release. They are defined approximately by $8^h50^m27^s$ to $8^h51^m11^s$ and $<8^h35^m27^s$. The resulting survey field has a size of 0.7 deg$^2$ and is illustrated in Figure 1. These data are shown on the diagram of $i$--$K_s$ versus $H$ in Figure 2. We also include the 10 Myr isochrone from Baraffe et al. (1998) for masses of 0.015--1 $M_\odot$ at a distance of 97 pc (Mamajek et al. 1999). This isochrone was converted to photometric magnitudes from predicted effective temperatures and bolometric luminosities in the manner described by Luhman et al. (2003a).

To separate candidate members of $\eta$ Cha from likely field stars, we defined a boundary that is below this isochrone. To account for the larger photometric errors that would be exhibited by any members at the faintest levels, we placed the boundary at a larger distance below the isochrone at lower masses. Above this boundary, there are 22 stars that are not previously known members. We selected 16 of these candidates for spectroscopy. Among the six remaining sources, three stars were already classified as field giants by Lawson et al. (2002). The other three candidates, 2MASS J08501189$^\circ$7844236, J08382996$^\circ$7924507, and J08501972$^\circ$7906344, were not observed because they are likely to be field giants according to their $J$--$H$ and $H$--$K_s$ colors, as shown in Figure 3. The 12 known members at K and M spectral types were included in our spectroscopic sample as well. Table 1 summarizes long-slit spectroscopy of these 28 targets. The observing and data reduction procedures are the same as those described by Luhman (2004).

2.2. Classification of Candidate Members

We measured spectral types and assessed membership for the 16 candidate members of $\eta$ Cha by applying the methods of classification described by Luhman (2004) for a similar set...
of data in Cha I. In this way, we classified 13 candidates as field dwarfs and background giants. Astrometry, photometry, and spectral types for these sources are listed in Table 2. We also include the three field stars identified spectroscopically by Lawson et al. (2002). Among the three remaining candidates, source 16 has emission in Hα (\(W_\lambda = 77\, \AA\)) that is above the levels observed for active field dwarfs (Gizis et al. 2000, 2002) and emission in He i at 6678 Å. Although emission lines of this kind can arise from flaring field dwarfs, the low duty cycle of such flares (Gizis et al. 2000) combined with the presence of these strong lines during the separate observations in this work and in Song et al. (2004) indicates that the emission source is probably a young star rather than a flaring field dwarf. The spectra of this object and the other two remaining candidates exhibit conclusive evidence of youth, and thus membership in \(\eta\) Cha, in the form of the weak K i and Na i absorption features that are characteristic of pre-main-sequence objects (Martín et al. 1996; Luhman 1999). These three new members were independently discovered in the survey by Song et al. (2004). Sources 17 and 18 were also reported by Lyo et al. (2004). The spectra of the three new members and the 12 previously known late-type members are presented in Figure 4. Astrometry, photometry, spectral types, and evidence of membership for the 18 known members of \(\eta\) Cha are compiled in Table 3. The I photometry from Lawson et al. (2001, 2002) and Lyo et al. (2004) agrees with the \(i\) data from DENIS for most of the members of \(\eta\) Cha, with the exception of the third brightest member, source 13 (HD 75505), for which \(i\) is fainter than \(I\). The two brightest stars, sources 2 and 8 (\(\eta\) Cha and RS Cha), were not measured at \(i\), but their \(i\) data are also much fainter than expected relative to the IR photometry from 2MASS. Therefore, the DENIS \(i\) measurements for these three members are not included in Table 3.

### 2.3. Completeness of Survey

Because low-mass, cool sources are most easily detected at near-IR wavelengths, we use the diagram of \(H - K_s\) versus \(H\) in Figure 5 to evaluate the mass completeness of our survey for new members of \(\eta\) Cha. The completeness limits of the 2MASS photometry are taken to be the magnitudes at which the logarithm of the number of sources as a function of magnitude departs from a linear slope and begins to turn over (\(H \sim 15.5, K_s \sim 15.25\)). Without quantitative support, Song et al. (2004) asserted that late-M members of \(\eta\) Cha are not present.

### Table 1

**Observing Log for \(\eta\) Cha**

| Date         | Grating (lines mm\(^{-1}\)) | Resolution (Å) | ID* |
|--------------|-----------------------------|-----------------|-----|
| 2003 May 1... | 600                         | 5              | 14, 15, 16, 17, J08381023—7842153, J08481929—7911034, J08483486—7853513, J08362667—7902260, J08492628—7900397 |
| 2003 May 2... | 600                         | 5              | 3, 4, 5, 6, 9, 10, 12, 13, J08430440—7837463, J08423433—7832282, J08439005—7844228, J08453547—7843596, J08491452—7848397, J08411327—7910044, J08432527—7910133, J08440502—7855289 |
| 2003 Jun 24... | 1200                        | 2.6            | 1, 7, 11, J08430440—7837463, J08423433—7832282, J08439005—7844228, J08453547—7843596, J08491452—7848397, J08411327—7910044, J08432527—7910133, J08440502—7855289 |

**Note.**—All observations were performed with the Magellan I telescope and the Boller & Chivens spectrograph.  

1. Identifications are from Table 3 for members of \(\eta\) Cha and from the 2MASS Point Source Catalog for the remaining stars.

2. Second DENIS Release.

### Table 2

**Field Stars toward \(\eta\) Cha**

| 2MASS         | \(\alpha(J2000.0)^{\circ}\) | \(\delta(J2000.0)^{\circ}\) | Spectral Type | References | Field Star Evidenceb | References | \(i^\prime\) | \(J-H^2\) | \(H-K_s^2\) | \(K_s^2\) |
|---------------|-----------------------------|-----------------------------|---------------|-------------|----------------------|-------------|-----------|----------|-----------|----------|
| J08362667—7902260..... | 08 36 26.67 | −79 02 26.1 | G8 III | 1 | Sp | 9.53 | 0.71 | 0.17 | 7.59 |
| J08364076—7854583..... | 08 36 40.77 | −78 54 58.3 | M2 III | 2 | Li, Sp, μ | 10.46 | 0.92 | 0.25 | 8.05 |
| J08375143—7844370..... | 08 37 51.44 | −78 44 37.1 | K5 III | 2 | Li, Sp, μ | 9.81 | 0.83 | 0.17 | 7.69 |
| J08381023—7842153..... | 08 38 10.23 | −78 42 15.4 | K2 III | 1 | Sp | 10.11 | 0.58 | 0.18 | 8.42 |
| J08411327—7910044..... | 08 41 13.28 | −79 10 04.5 | K2 III | 1 | Li, Sp | 9.22 | 0.70 | 0.20 | 7.16 |
| J08423433—7832282..... | 08 42 34.34 | −78 32 28.2 | K5 III | 1 | Li, Sp | 11.14 | 0.80 | 0.22 | 8.99 |
| J08430440—7837463..... | 08 43 04.41 | −78 37 46.3 | K4 III | 1 | Li, Sp | 10.83 | 0.72 | 0.27 | 8.71 |
| J08435227—7910133..... | 08 43 52.28 | −79 10 13.4 | K2 III | 1 | Li, Sp | 10.42 | 0.61 | 0.18 | 8.68 |
| J08440502—7855289..... | 08 44 05.03 | −78 55 28.9 | K1 III | 1 | Li, Sp | 8.93 | 0.52 | 0.18 | 7.23 |
| J08453547—7843596..... | 08 45 35.47 | −78 43 59.7 | K4 III | 1 | Li, Sp | 11.62 | 0.77 | 0.22 | 9.44 |
| J08481929—7911034..... | 08 48 19.29 | −79 11 03.4 | K2 III | 1 | Sp | 10.48 | 0.60 | 0.15 | 8.75 |
| J08483486—7853513..... | 08 48 34.87 | −78 53 51.4 | M5 V, M4.75 V | 2 | Li, μ, NaK | 14.08 | 0.54 | 0.31 | 11.38 |
| J08491452—7848397..... | 08 49 14.53 | −78 48 39.7 | K3—K4 III | 1 | Li, Sp | 11.56 | 0.81 | 0.19 | 9.52 |
| J08492628—7900397..... | 08 49 26.29 | −79 00 39.7 | K2 III | 1 | Sp | 10.44 | 0.67 | 0.15 | 8.70 |
| J08493005—7844228..... | 08 49 30.05 | −78 44 22.8 | K2 III | 1 | Li, Sp | 11.64 | 0.80 | 0.19 | 9.51 |
| J08512320—7905232..... | 08 51 23.20 | −79 05 23.2 | K4 III | 2 | Li, Sp, μ | 9.78 | 0.67 | 0.20 | 7.77 |

**Note.**—Units of right ascension are hours, minutes, and seconds, and units of declination are degrees, arcminutes, and arcseconds.

1. 2MASS Point Source Catalog.
2. Status as a field star is indicated by a spectral classification as a dwarf or a giant ("Sp"), weak Li absorption ("Li"), strong Na i and K i absorption ("NaK"), or a proper motion that differs from that of the known members of \(\eta\) Cha ("μ").
detectable with data from 2MASS. However, according to the evolutionary models of Baraffe et al. (1998), the completeness limits of the 2MASS data correspond to a mass of \(0.015 \, M_\odot\) and a spectral type of \(\sim L0\) for objects at the age and distance of the association (6 Myr, 97 pc).

In Figure 5 we have plotted the theoretical isochrone from Baraffe et al. (1998) for 10 Myr, which is near the upper limit we find for the age of the \(\eta\) Cha association (\S\ 2.4). We have omitted the field stars identified with spectroscopy, as well as objects that are probable field giants by their location below the boundary in Figure 2. The three stars lacking spectroscopy that were identified as likely field giants by Figure 3 are also excluded. The remaining IR sources consist of known members of the association and objects that were not detected at the \(i\) band by DENIS. As demonstrated in Figure 5, our search for new members is complete to masses of \(0.015 \, M_\odot\), which is near the deuterium-burning mass limit (Burrows et al. 1997).

2.4. H-R Diagram

In this section we estimate effective temperatures and bolometric luminosities for the members of \(\eta\) Cha, place these data on the H-R diagram, and use theoretical evolutionary models to infer masses and ages.

In the following analysis standard dwarf colors are taken from the compilation of Kenyon & Hartmann (1995) for types earlier than M0 and from the young disk populations described by Leggett (1992) for types of M0 and later. The IR colors from Kenyon & Hartmann (1995) are transformed from the Johnson-Glass photometric system to the Caltech (CIT) system (Bessell & Brett 1988). Near-IR colors in the 2MASS and CIT photometric systems agree at a level of less than 0.1 mag (Carpenter 2001).

To estimate the amount of extinction toward each member of \(\eta\) Cha, Luhman (2001) compared the \(V-I\) color from Lawson et al. (2001) to the value for a dwarf at the published spectral type of that source. The resulting extinctions ranged from \(A_V = 0\) to 0.8. However, when we include \(V-R\) and \(R-I\) colors in this analysis and use the spectral types measured in this work, we arrive at extinctions that are close to zero for most of the members. A comparison of our spectra to the estimates of unreddened spectra of young stars from Luhman (2004) also indicates essentially no extinction, with a firm limit of \(A_V < 0.5\) for most members. Therefore, we take \(A_V = 0\) when computing bolometric luminosities from the observed photometry. The one exception is source 13 (HD 75505), whose optical colors do imply a nonzero extinction of \(A_V = 0.4\).

Spectral types of M0 and earlier are converted to effective temperatures with the dwarf temperature scale of Schmidt-Kaler (1982). For spectral types later than M0, we use the temperature scale that was designed by Luhman et al. (2003b) to be compatible with the models of Baraffe et al. (1998) and Chabrier et al. (2000). Bolometric luminosities are estimated by combining \(J\)-band measurements, a distance of 97 pc, and bolometric corrections described in Luhman (1999). The combined uncertainties in \(A_V\), \(J\), and \(BC_J\) (\(\sigma \sim 0.14\), 0.03, and 0.1, respectively) correspond to errors of \(\pm 0.07\) in the relative values of \(\log L_\text{bol}\). When an uncertainty in the distance modulus is included (\(\sigma \sim 0.1\)), the total uncertainties are \(\pm 0.12\). The temperatures and luminosities of the components of the binary system source 8 (RS Cha) are from Ribas et al. (2000) and Mamajek et al. (2000), respectively. Two additional known binaries among the members of \(\eta\) Cha are sources 1 and 9 (Köhler & Petr-Gotzens 2002). The luminosities plotted on the H-R diagram in Figure 6 are corrected for the contribution of the secondary by assuming that for each system, the ratio of the luminosities is equal to the ratio of the \(K\)-band fluxes from Köhler & Petr-Gotzens (2002). Meanwhile, the luminosities in Table 3 are uncorrected and reflect the total system photometry. The effective temperatures, bolometric luminosities, and adopted spectral types for the members of \(\eta\) Cha are listed in Table 3.

The temperatures and luminosities for the members of \(\eta\) Cha can be interpreted in terms of masses and ages with theoretical evolutionary models. After considering the available sets of models, Luhman et al. (2003b) concluded that those of Palla & Stahler (1999) for \(M/M_\odot > 1\) and Baraffe et al. (1998) and Chabrier et al. (2000) for \(M/M_\odot \leq 1\) provided the best agreement with observational constraints. The known members of \(\eta\) Cha are plotted with these models on the H-R diagram in Figure 6. One member, source 12, appears overluminous compared to the other sources and thus may be an unresolved binary. Otherwise, the remaining members form a relatively narrow, well-defined sequence that is parallel to the model isochrones and is consistent with a single age of \(6^{\pm 2}_1\) Myr for all members. This age agrees within the uncertainties with previous estimates by Mamajek et al. (1999) and Lawson et al. (2001). According to the H-R diagram and evolutionary models in Figure 6, the three newly discovered members of \(\eta\) Cha have masses of \(0.08-0.13 \, M_\odot\), and thus are just above and straddling the hydrogen-burning mass limit.

2.5. Implications of the Survey

We now examine the implications of our survey of the \(\eta\) Cha association. We have identified three new members just above the hydrogen-burning limit but have found no objects at lower masses down to the completeness limit of \(0.015 \, M_\odot\). Is this result consistent with the mass functions measured in younger, star-forming clusters? In Taurus and IC 348, the ratio of the number of brown dwarfs at \(0.02-0.08 \, M_\odot\) to the number of...
### Table 3
Data for Members of \( \eta \) Chamaeleontis

| IDa | Other Names | \( \alpha (J2000.0) \)b | \( \delta (J2000.0) \)b | Spectral Typec | Referencesd | Adopted Spectral Type | Membership Evidencee | Referencesd | \( T_{\text{eff}} \)f | \( L_{\text{bol}} \)g | \( V-R \)h | \( R-I \)h | \( I \)h | \( J-H \)h | \( H-K_s \)h | \( K_s \)h |
|-----|-------------|--------------------------|--------------------------|---------------|-------------|----------------------|----------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| 1... | GSC 9402-0921 | 08 36 56.23 | –78 56 45.5 | K4, K4, K6 | 1, 2, 3 | K6 | \( \mu \), Li | 2, (1, 2) | 4205 | 1.0 | 0.71 | 0.71 | 9.19 | 9.17 | 0.66 | 0.16 | 7.34 |
| 2... | \( \eta \) Cha | 08 41 19.48 | –78 57 48.1 | B8 | 4, 2 | B8 | \( \mu \), \( \pi \) | 2 | 11900 | 94 | ... | ... | ... | ... | –0.03 | 0.00 | 5.72 |
| 3... | ... | 08 41 37.03 | –79 03 30.4 | M3, M3.25 | 2, 3 | M3.25 | Li, NaK | 2, 3 | 3379 | 0.097 | 1.14 | 1.40 | 11.81 | 11.70 | 0.70 | 0.23 | 9.41 |
| 4... | GSC 9403-1083 | 08 42 23.73 | –79 04 03.0 | K7, M1.75 | 2, 3 | M1.75 | Li | 2 | 3596 | 0.24 | 0.92 | 1.07 | 10.79 | 10.71 | 0.76 | 0.16 | 8.62 |
| 5... | ... | 08 42 27.11 | –78 54 42.8 | M3, M4 | 2, 3 | M3 | Li, NaK | 2, 3 | 3415 | 0.11 | 1.00 | 1.40 | 11.68 | 11.64 | 0.65 | 0.29 | 9.29 |
| 6... | GSC 9403-0288 | 08 42 38.80 | –79 07 24.5 | K4, K3, K6 | 1, 2, 3 | K6 | Li | 2 | 4205 | 0.79 | 0.67 | 0.73 | 9.44 | 9.40 | 0.66 | 0.12 | 7.63 |
| 7... | Anonymous | 08 43 07.24 | –79 08 42.8 | K4, K5.5 | 2, 3 | K5.5 | Li | 2, 3 | 3379 | 0.097 | 1.14 | 1.40 | 11.81 | 11.70 | 0.70 | 0.23 | 9.41 |
| 8A... | RS Cha A | 08 43 12.30 | –79 08 42.8 | A7 | 2 | A7 | \( \mu \), \( \pi \) | 2 | 7638 | 13.9 | ... | ... | ... | ... | 0.12 | 0.02 | 5.85 |
| 8B... | RS Cha B | 08 43 12.30 | –79 08 42.8 | ... | ... | ... | ... | ... | 7228 | 13.4 | ... | ... | ... | ... | ... | ... | ... |
| 9... | ... | 08 44 16.38 | –78 59 08.1 | M4, M4.5 | 2, 3 | M4.5 | Li, E, \( \mu \), NaK | 2, 2, 5, 3 | 3198 | 0.096 | 1.36 | 1.63 | 12.01 | 11.98 | 0.59 | 0.33 | 9.34 |
| 10... | GSC 9403-1279 | 08 44 31.88 | –78 46 31.2 | K7–M0, K7, M1 | 1, 2, 3 | M1 | Li, \( \mu \) | (1, 2), 5 | 3705 | 0.23 | 0.86 | 0.92 | 10.75 | 10.71 | 0.73 | 0.19 | 8.73 |
| 11... | GSC 9403-1016 | 08 47 01.66 | –78 59 34.5 | K4, K5.5 | 2, 3 | K5.5 | Li, \( \mu \) | 2, 5 | 4278 | 0.59 | 0.66 | 0.71 | 9.76 | 9.84 | 0.70 | 0.37 | 7.66 |
| 12... | GSC 9403-0389 | 08 47 56.77 | –79 04 52.5 | M3, M4, M4.5 | 2, 3 | M4.5 | Li, NaK | (1, 2), 5, 3 | 3379 | 0.25 | 1.07 | 1.30 | 10.80 | 10.83 | 0.64 | 0.27 | 8.41 |
| 13... | HD 75505 | 08 44 47.22 | –78 02 53.1 | ... | ... | ... | ... | ... | 7228 | 13.4 | ... | ... | ... | ... | ... | ... | ... |
| 14... | USNO Anon 1 | 08 44 31.30 | –78 53 06.5 | M4, M4.75 | 6, 3 | M4.75 | Li, NaK | 6, 3 | 3161 | 0.023 | 1.52 | 1.73 | 13.82 | 13.58 | 0.57 | 0.26 | 10.98 |
| 15... | USNO Anon 2 | 08 43 18.58 | –79 05 18.2 | M2–M3, M3.25 | 6, 3 | M3.25 | Li, E, NaK | 6, (6, 3), 3 | 3379 | 0.083 | 0.99 | 1.21 | 11.77 | 11.81 | 0.67 | 0.40 | 9.43 |
| 16... | ... | 08 44 09.15 | –78 33 45.7 | M4.5–M5.5, M5.75 | 7, 3 | M5.75 | Li, E, NaK | 7, (7, 3), 3 | 3024 | 0.010 | 0.09 | 0.12 | 14.79 | 14.82 | 0.53 | 0.36 | 11.62 |
| 17... | ... | 08 38 51.50 | –79 16 13.7 | ... | ... | ... | ... | ... | 14.79 | 0.53 | 0.36 | 11.62 | ... | ... | ... | ... | ... |
| 18... | ... | 08 36 10.73 | –79 08 18.4 | ... | ... | ... | ... | ... | 14.79 | 0.53 | 0.36 | 11.62 | ... | ... | ... | ... | ... |

Note.—Units of right ascension are hours, minutes, and seconds, and units of declination are degrees, arcminutes, and arcseconds.

a Identification numbers 1–12 are ROSAT \( \eta \) Cha X-ray designations from Mamajek et al. (1999). Identifications 13–18 are assigned in this work.
b 2MASS Point Source Catalog.
c Measurement uncertainties for the spectral types from this work are \( \pm 0.5 \) and 0.25 subclasses for K and M types, respectively.
d References correspond on a one-to-one basis with the previous column, with references in parentheses grouped together.
e Membership in \( \eta \) Cha is indicated by strong emission in H\( \alpha \) ("E"), Na i and K i strengths intermediate between those of dwarfs and giants ("NaK"), strong Li absorption ("Li"), or a proper motion ("\( \mu \)\)) or parallax ("\( \pi \)\)) that is similar to that of the known members of \( \eta \) Cha.
f Temperature scale from Schmidt-Kaler (1982) (\( \geq M_0 \)) and Luhman et al. (2003b) (\( > M_0 \)), except for RS Cha A and B, where the temperatures are from Ribas et al. (2000).
g Lawson et al. (2001) and Lyo et al. (2004).
h Second DENIS Release.

References.—(1) Covino et al. 1997; (2) Mamajek et al. 1999; (3) this work; (4) Houk & Cowley 1975; (5) Lawson et al. 2001; (6) Lawson et al. 2002; (7) Song et al. 2004; (8) Lyo et al. 2004.
stars has been measured to be 0.13 (Briceño et al. 2002; Luhman et al. 2003a, 2003b). If this ratio applies to \( \eta \) Cha, then we would expect to find only 2.3 substellar members in this mass range. Therefore, the lack of any detected brown dwarfs does not comprise a statistically significant difference from mass functions in these two populations. Meanwhile, \( \eta \) Cha does appear to differ at a modestly significant level from the Trapezium Cluster in Orion, which exhibits a frequency of brown dwarfs that is about twice the value found in Taurus and IC 348 (Luhman et al. 2000; Hillenbrand & Carpenter 2000; Muench et al. 2002).

As illustrated in Figure 1, the three members of \( \eta \) Cha with the lowest masses do have the largest angular separations from the center of the association, which is suggestive of mass segregation and could indicate that substellar members of the association are preferentially located in the outskirts of the association and beyond our survey field. The possibility of the formation of a low-mass halo in \( \eta \) Cha through dynamical evolution was discussed by Mamajek et al. (2000). A survey like the one performed in this work for a larger area toward \( \eta \) Cha would provide a test of this scenario. Finally, we note that Lyo et al. (2004) predicted the presence of at least 20 undiscovered members at masses of 0.025–0.15 \( M_\odot \) based on an extrapolation of the initial mass function of the known members. However, we demonstrate that only one new member beyond the census of Lyo et al. (2004) is present in this mass range.

### 3. MBM 12A

#### 3.1. Selection of Candidate Members

In a recent search for members of MBM 12A, Ogura et al. (2003) identified four objects as probable members of the association through slitless grism spectroscopy. Two of these sources were in the spectroscopic sample of Luhman (2001), and the other two stars are included in our sample here. At the end of the survey for new members of MBM 12A by Luhman (2001), there remained six candidates that had not been observed spectroscopically. In this work we selected the three brightest candidates for spectroscopy, 2MASS J02524907+1952523, J02585238+1958402, and J02583445+1946506. To facilitate the classification of the spectra of the candidates, we also observed the known member MBM 12A 3. Table 4 summarizes our long-slit spectroscopy of these targets.

#### 3.2. Classification of Candidate Members

Ogura et al. (2003) obtained slitless grism spectroscopy toward the MBM 12 cloud and identified four stars as probable members of MBM 12A on the basis of emission in H\( \alpha \).

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**TABLE 4**

| Date       | Telescope + Instrument | Grating (lines mm\(^{-1}\)) | Resolution (Å) | IDa |
|------------|------------------------|-----------------------------|----------------|-----|
| 2002 Jan 12 | MMT + Blue Channel     | 600                         | 2.8            | J02524907+1952523, J02583445+1946506, J02585238+1958402 |
| 2003 Dec 14 | MMT + Red Channel      | 1200                        | 2.1            | MBM 12A 3, J02562431+2035117, J02573101+1943459 |

a Identifications are from the 2MASS Point Source Catalog, except for MBM 12A 3, which is from Luhman (2001).
The two sources from Ogura et al. (2003), 2MASS J02562431+1958402, are not present in the spectra obtained in this work for the other configuration is included for comparison. Similarly, Li absorption members MBM 12A 3 obtained with the same instrument concerns, as shown in Figure 7, where a spectrum of the known classified as field dwarfs through spectroscopy of Li by and 2MASS J02575018+1958302 (Byu 4), had already been four candidates therein, 2MASS J02553502+2006484 (Byu 1) youth. Prior to the study of Ogura et al. (2003), two of the strong Li absorption at 6707 Å. However, Hα emission also occurs in field dwarfs and thus can serve as evidence of youth and membership only if it is above the levels observed in active dwarfs. For instance, the equivalent widths from Ogura et al. (2003) for three of the four sources are less than 10 Å, which is within the range observed for field M dwarfs (Gizis et al. 2002). For Hα in the fourth star, they report an equivalent width of 56.4 Å, while we measure only 10 Å. We suggest that the measurement from Ogura et al. (2003) is either spurious or obtained during a flare. In summary, the Hα strengths for these four sources are consistent with both field dwarfs and young members of MBM 12A, and hence cannot be used to assess membership in the association.

To conclusively determine the membership of the four objects from Ogura et al. (2003), we checked for the presence of strong Li absorption at 6707 Å, which is a signature of youth. Prior to the study of Ogura et al. (2003), two of the four candidates therein, 2MASS J02553502+2006484 (Byu 1) and 2MASS J02575018+1958302 (Byu 4), had already been classified as field dwarfs through spectroscopy of Li by Luhman (2001). Those data exhibit a clear absence of Li absorption, as shown in Figure 7, where a spectrum of the known member MBM 12A 3 obtained with the same instrument configuration is included for comparison. Similarly, Li absorption is not present in the spectra obtained in this work for the other two sources from Ogura et al. (2003), 2MASS J02562431+2035117 (Byu 2) and 2MASS J02573101+1943459 (Byu 3). Membership in MBM 12A for these two stars would have been somewhat surprising given their location below the boundary in the R−I versus I diagram from Luhman (2001), which is the reason they were not observed spectroscopically or listed as candidates in that work.

Luhman (2001) found that the optical and near-IR colors of 2MASS J02524907+1952523, J02583445+1946506, and J02585238+1958402 were consistent with those of unreddened stars at spectral types of M4−M5, either foreground dwarfs or young members of MBM 12A. From the spectra collected for these objects, we have measured spectral types of M3.5 V, M4.75 V, and M4.75−M5 V, which are in agreement with the estimates from the photometry. Given the lack of Li absorption in the spectra in Figure 7, we classify these stars as field dwarfs.

4. CONCLUSIONS

We have performed spectroscopic studies of candidate members of the η Cha and MBM 12A young associations, the conclusions for which are summarized below.

For η Cha, we have used JHKs photometry from 2MASS and i photometry from DENIS to construct color-color and color-magnitude diagrams for an area of 0.7 deg². Through spectroscopy of the candidate members appearing in these data, we have discovered three new members of the association with spectral types of M5.25−M5.75, corresponding to masses of 0.13−0.08 M☉ according to evolutionary models. These sources were independently found in recent works by Song et al. (2004) and Lyo et al. (2004). No brown dwarfs were detected in η Cha down to the completeness limit of 0.015 M☉ for our survey, which is roughly consistent with the yield of ~2 substellar members expected if the relative numbers of stars and brown dwarfs in η Cha are similar to those of the Taurus and IC 348 star-forming regions. On the other hand, the fact that the three least massive members of the association are the outermost members may indicate that the substellar members are preferentially located at large distances from the center of the association and outside of our survey field. For the 18 known members of η Cha, we have estimated bolometric luminosities and effective temperatures and placed the members on the H−R diagram, from which we infer an age of ~2−3 Myr for the association with the evolutionary models of Baraffe et al. (1998).

For MBM 12A, we have presented spectra of three of the remaining candidate members that lacked spectroscopy at the end of the survey by Luhman (2001) and of the four probable members from Ogura et al. (2003). We classify all of these sources as field dwarfs based on the absence of Li absorption in their spectra.

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