

Chamaeleon

Kevin L. Luhman

Department of Astronomy and Astrophysics
The Pennsylvania State University
University Park, PA 16802, USA

Abstract. The dark clouds in the constellation of Chamaeleon have distances of 160-180 pc from the Sun and a total mass of $\sim 5000 M_{\odot}$. The three main clouds, Cha I, II, and III, have angular sizes of a few square degrees and maximum extinctions of $A_V \sim 5-10$. Most of the star formation in these clouds is occurring in Cha I, with the remainder in Cha II. The current census of Cha I contains 237 known members, 33 of which have spectral types indicative of brown dwarfs ($> M6$). Approximately 50 members of Cha II have been identified, including a few brown dwarfs. When interpreted with the evolutionary models of Chabrier and Baraffe, the H-R diagram for Cha I exhibits a median age of ~ 2 Myr, making it coeval with IC 348 and slightly older than Taurus (~ 1 Myr). The IMF of Cha I reaches a maximum at a mass of 0.1-0.15 $M_{\odot}$, and thus closely resembles the IMFs in IC 348 and the Orion Nebula Cluster. The disk fraction in Cha I is roughly constant at $\sim 50\%$ from 0.01 to 0.3 $M_{\odot}$ and increases to $\sim 65\%$ at higher masses. In comparison, IC 348 has a similar disk fraction at low masses but a much lower disk fraction at $M \gtrsim 1 M_{\odot}$, indicating that solar-type stars have longer disk lifetimes in Cha I.

1. Introduction

The southern constellation of Chamaeleon contains one of the nearest groups of dark clouds to the Sun ($d \sim 160-180$ pc). An extinction map of these clouds is shown in Figure 1 (Dobashi et al. 2005). The main clouds in Chamaeleon have angular sizes of a few square degrees and are referred to as Chamaeleon I, II, and III (Hoffmeister 1962).¹ Digitized Sky Survey (DSS) images of Cha I and II are shown in Figure 2 and a color optical image of Cha I obtained by G. Rhemann is shown in Figure 3. These clouds contain signposts of recent star formation in the form of several reflection nebulae, including Ced 110, 111, and 112 (Cederblad 1946) and the Infrared Nebula (IRN, Schwartz & Henize 1983). An optical image of the area surrounding Ced 111 is shown in Figure 4. Newborn stars were first directly discovered in Chamaeleon through their variability and H α emission (Hoffmeister 1962; Henize 1963; Mendoza 1972). The masses of the Chamaeleon clouds and the stellar densities of young stars within them are low compared to many other star-forming regions. Because Chamaeleon is nearby and well-isolated from other young stellar populations, it has been a popular target for studies of low-mass star formation.

¹In most publications, including this review, the designations Cha II and Cha III have been reversed from the original ones assigned by Hoffmeister (1962).

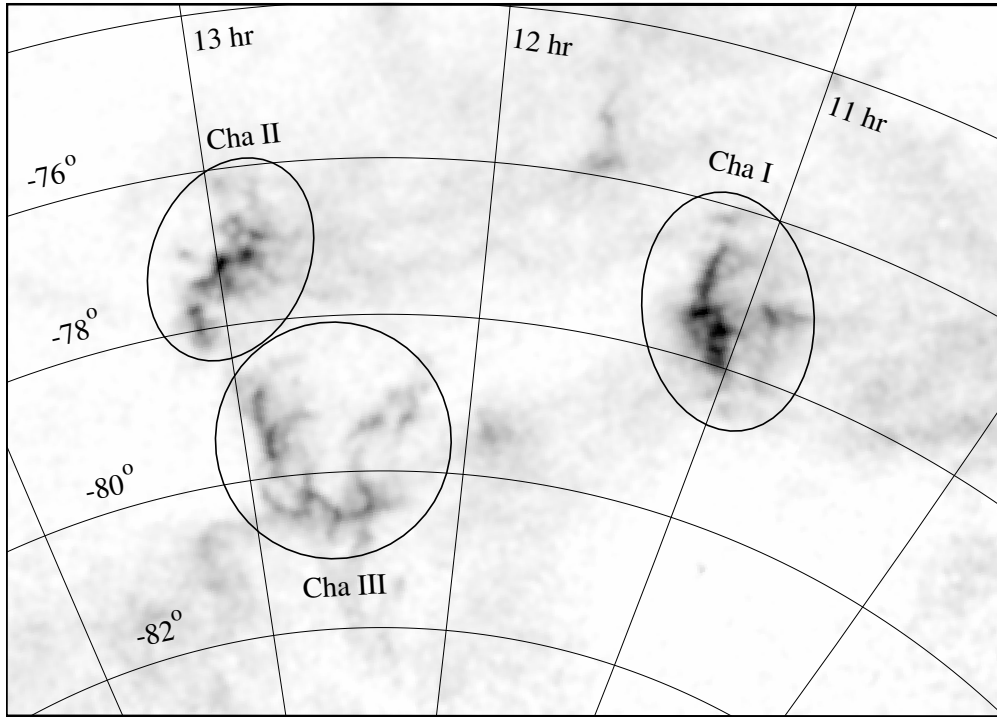


Figure 1. Extinction map of the Chamaeleon dark clouds (Dobashi et al. 2005). The maximum extinction in this map is $A_V \sim 10$.

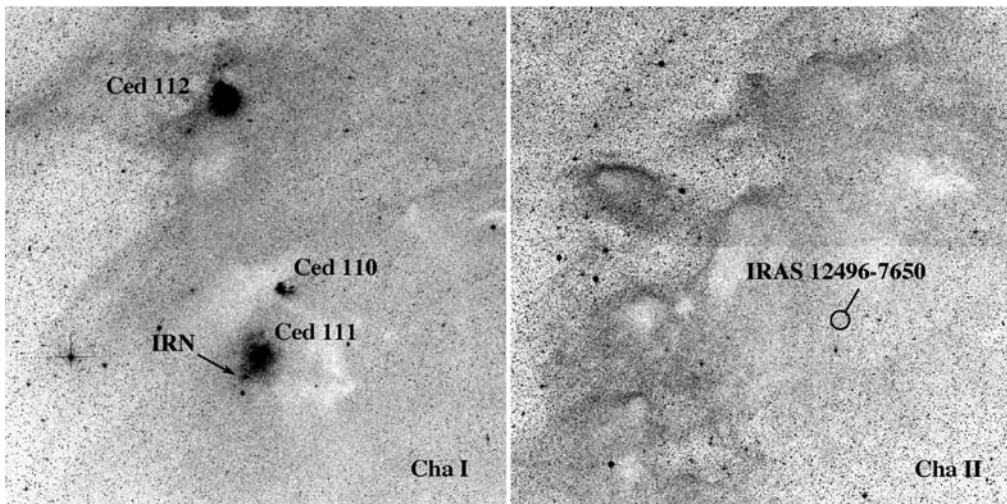


Figure 2. DSS images of Cha I ($2^\circ \times 2^\circ$) and Cha II ($1.5^\circ \times 1.5^\circ$). The reflection nebulae Ced 111 and Ced 112 are associated with the B stars HD 97048 and HD 97300, respectively.



Figure 3. A wide-field optical color-composite image of the Cha I cloud ($1.4 \times 2^\circ$). North is up and east is left. Courtesy G. Rhemann.

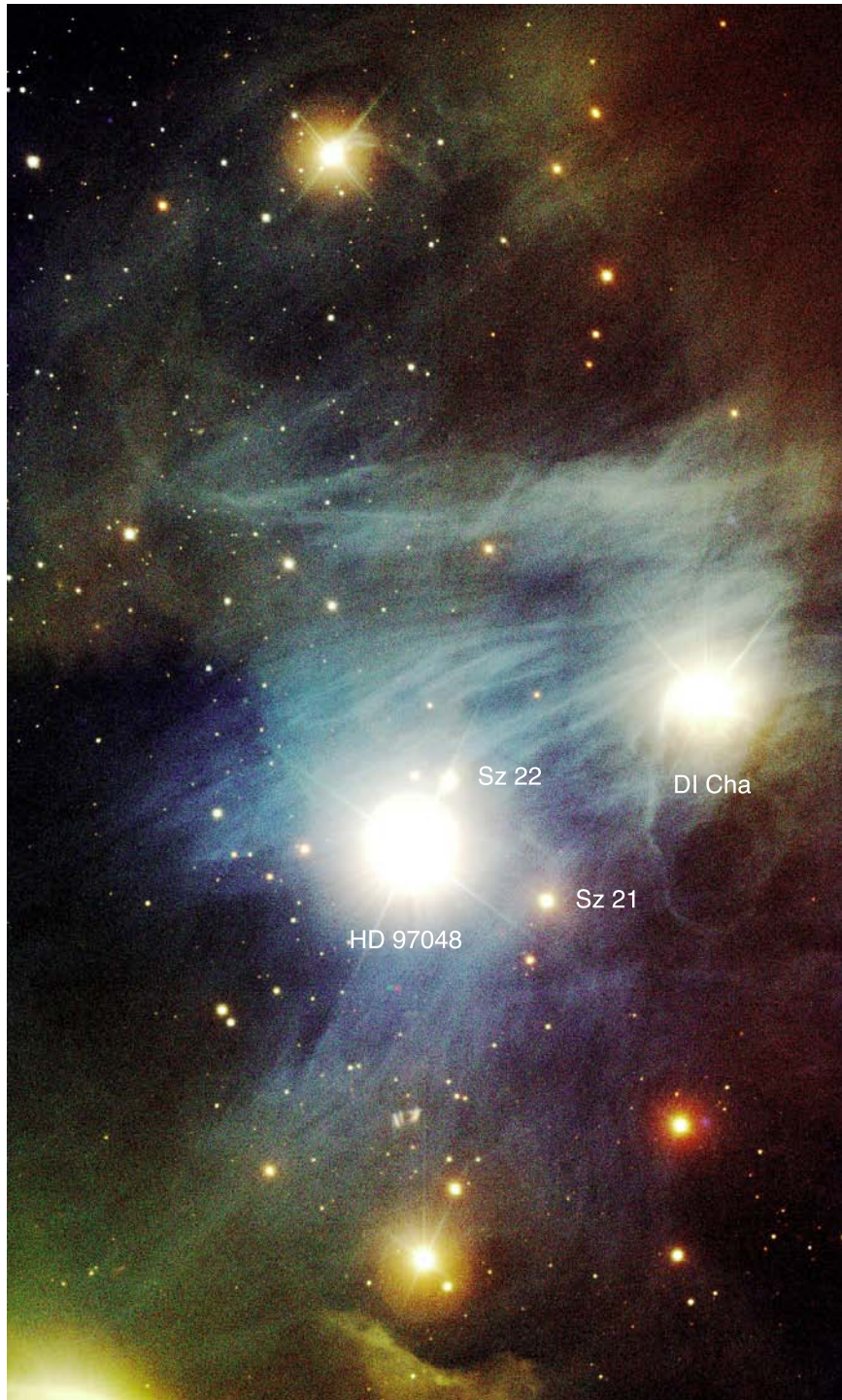


Figure 4. An optical color-composite image of the Ced 111 reflection nebula in Cha I obtained with VLT ($6\frac{1}{8} \times 11\frac{1}{2}$). Four of the brightest young stars within this area are labeled. North is up and east is left. Courtesy ESO.

2. Distance

Published distance estimates for Cha I have ranged from 115 to 215 pc (Schwartz 1991). The newest measurements by Whittet et al. (1997), Bertout et al. (1999), and Wichmann et al. (1998) are revisited in this section. Whittet et al. (1987) measured a distance to Cha I by examining the distribution of extinction as a function of distance for stars projected against the cloud. That analysis was updated with newer photometry by Whittet et al. (1997), who derived lower and upper limits of 135 and 165 pc. Whittet et al. (1997) measured a second distance of 152 ± 18 pc by assuming that HD 97300, which illuminates Ced 112, was on the zero age main sequence (ZAMS). They also considered the Hipparcos distances of 190 ± 40 and 180 ± 20 pc for HD 97300 and HD 97048 (Perryman et al. 1997). By combining these four distance constraints, Whittet et al. (1997) arrived at a final value of 160 ± 15 pc. Although the strengths of the hydrogen lines in HD 97300 are consistent with those expected of a ZAMS star (Grasdalen et al. 1975), the distance based on the ZAMS assumption is not used in this review. Bertout et al. (1999) estimated the distance of Cha I using the Hipparcos measurements for young stars associated with the cloud. Among those stars, only HD 97300, HD 97048, and CR Cha have both definitive evidence of membership in the cloud and robust Hipparcos distances (i.e., empty H59 field in the Hipparcos catalog). The weighted average of the parallaxes for these three stars corresponds to 175^{+20}_{-16} pc. In comparison, Wichmann et al. (1998) used the Hipparcos data for CR Cha, HIP 54738, and T Cha to estimate the distance of Cha I. However, HIP 54738 probably should be omitted because its H59 field in the Hipparcos catalog indicates that it may be an astrometric binary and T Cha is not a member of Cha I. Therefore, 175^{+20}_{-16} pc appears to be the most appropriate measurement from Hipparcos for stars in the cloud. The combination of this distance and the constraint of 135-165 pc from the extinction analysis of Whittet et al. (1997) indicates a best estimate of 160-165 pc for Cha I.

The various published distances for Cha II are summarized by Whittet et al. (1997). As they did for Cha I, Whittet et al. (1997) updated the previous measurements of extinction as a function of distance for stars toward Cha II (Franco 1991; Hughes & Hartigan 1992), arriving at a distance of 178 ± 18 pc for the cloud. Thus, the distance of Cha II is equal to or slightly greater than that of Cha I.

3. Cloud Structure

The most obvious signature of a dark cloud is, of course, the darkness it imposes on the background star population. Extinction maps with resolutions of a few arcminutes have been measured for the Chamaeleon clouds using optical (Toriseva & Mattila 1985; Gregorio-Hetem et al. 1988) and IR (Cambr  sy et al. 1997) star counts. The maximum extinction in these maps is $A_V \sim 10$, which occurs in Cha I (Cambr  sy et al. 1997). The levels of extinction in Chamaeleon are modest compared to many other dark clouds. Chamaeleon also has been mapped in molecules such as $C^{18}O$ (Toriseva et al. 1990; Mizuno et al. 1999; Hayakawa et al. 2001; Gahm et al. 2002; Haikala et al. 2005), ^{12}CO (Boulanger et al. 1998; Mizuno et al. 2001), and ^{13}CO (Mizuno et al. 1998; Hayakawa et al. 2001; Gahm et al. 2002). The ^{12}CO map from Mizuno et al. (2001) is shown in Figure 5. Based on these maps, Cha I has a total mass of $\sim 1000 M_\odot$ and Cha II and III each have masses of 1500-2000 $M_\odot$ (e.g., Boulanger et al. 1998; Mizuno et al. 2001). Various combinations of maps in molecules, far-IR continuum, H I, extinc-

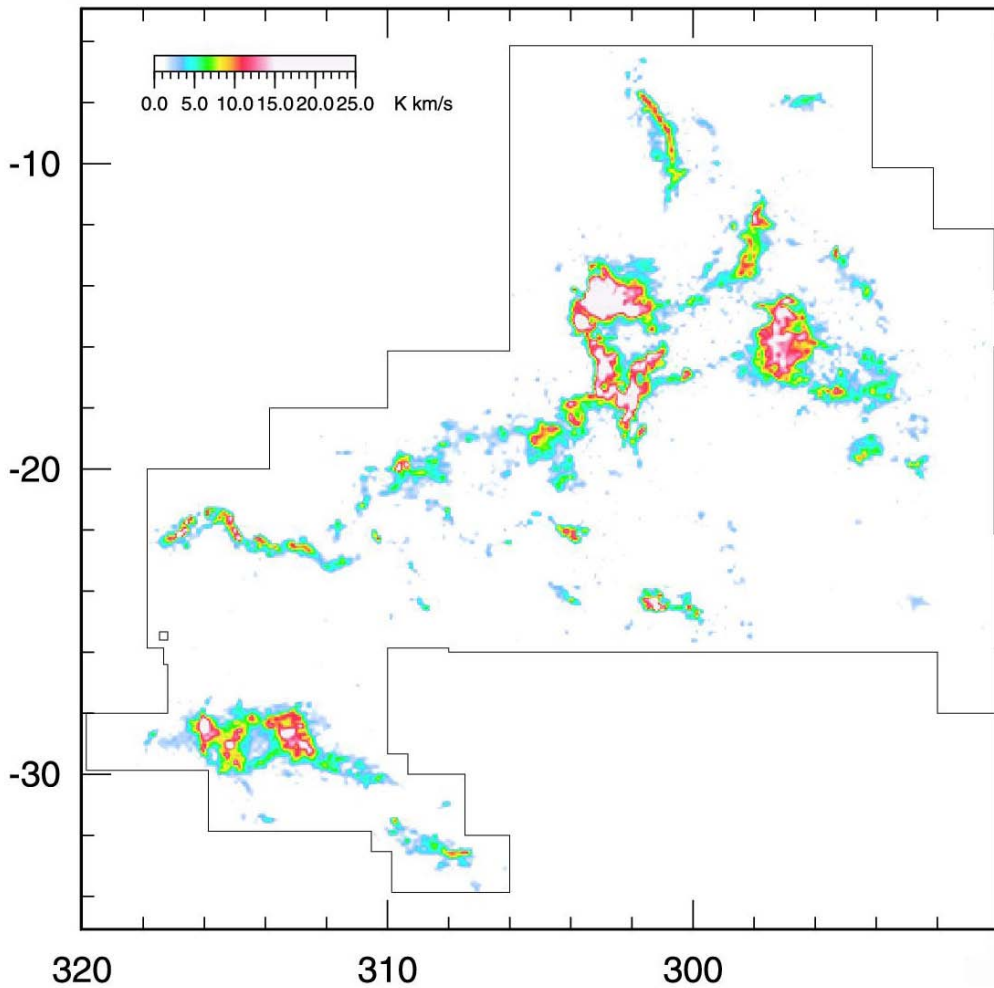


Figure 5. A large-scale ^{12}CO ($J = 1-0$) total-intensity map of the area surrounding the Chamaeleon clouds obtained with the NANTEN telescope (Mizuno et al. 2001). The x-axis is Galactic longitude and the y-axis is Galactic latitude. The boundaries of the observed area are indicated (*solid lines*).

tion, and polarization toward field stars have been used to study the properties of the interstellar medium and magnetic field in the Chamaeleon clouds (Whittet et al. 1994; McGregor et al. 1994; Harjunpää & Mattila 1996; Covino et al. 1997b; Boulanger et al. 1998; Hayakawa et al. 1999; Kainulainen et al. 2006; Naoi et al. 2006). A particularly notable characteristic of the interstellar medium in Chamaeleon is its unusually high value of $R_V \equiv A_V/E(B - V)$, which ranges between 5-6 (Grasdalen et al. 1975; Rydgren 1980; Vrba & Rydgren 1984; Steenman & Thi 1989; Whittet et al. 1994, 1987, 1997; Luhman 2004a). Chiar et al. (2007) obtained mid-IR spectroscopy of field giants behind Cha I and other molecular clouds and compared the optical depth of the $9.7 \mu\text{m}$ silicate feature in these data to near-IR color excesses. Unlike the diffuse interstellar medium, these clouds did not show monotonically increasing silicate absorption

with extinction, indicating the presence of grain growth. Many surveys also have targeted the interstellar medium near individual dense cores and young stellar objects in Chamaeleon, which have included maps in CS and CO (Olmi et al. 1994, 1997; Belloche et al. 2006; Löhner et al. 2007), HCN and HNC (Tennekes et al. 2006), and continua at far-IR (Lehtinen et al. 2001), millimeter (Henning et al. 1993; Reipurth et al. 1996), and centimeter (Lehtinen et al. 2003) wavelengths. One of the most popular targets has been the millimeter source Cha-MMS1 within the Ced 110 reflection nebula, which is probably in the Class 0 stage or in an earlier, prestellar phase (Reipurth et al. 1996; Lehtinen et al. 2001, 2003; Belloche et al. 2006; Tennekes et al. 2006). In addition, the Herbig AeBe stars associated with Ced 111 and 112, HD 97048 and HD 97300, have been imaged in mid-IR emission bands (Siebenmorgen et al. 1998, 2000) and the environment of IRN has been observed through IR photometry, spectroscopy, and polarimetry (Cohen & Schwartz 1984; Feldt et al. 1998; Ageorges et al. 1996; Gledhill et al. 1996). Solid methanol has been detected in the Cha I cloud through mid-IR spectroscopy of the Class I object Cha INa 2, also known as ISO 192 (Pontoppidan et al. 2003).

4. Stellar Population

A variety of signatures of youth have been used to search for young stars and brown dwarfs in the Chamaeleon clouds, including $H\alpha$ emission, variability, X-ray emission, and IR excess emission. Many of the candidates identified with these diagnostics also have been observed spectroscopically to provide spectral types and conclusive evidence of youth and membership. Summaries of these search methods and compilations of known members of Chamaeleon have appeared periodically in the literature (e.g., Whittet et al. 1987; Gauvin & Strom 1992; Carpenter et al. 2002; Luhman 2004a), and updated ones are provided in this section.

4.1. $H\alpha$

Many of the first candidate members of the Chamaeleon clouds were found during $H\alpha$ objective prism surveys (Henize 1963; Mendoza 1972; Henize & Mendoza 1973; Schwartz 1977; Harju et al. 1993). Followup optical photometry and spectroscopy were then performed on these candidates (Appenzeller 1977, 1979; Rydgren 1980; Appenzeller et al. 1983). A deeper $H\alpha$ survey of the southern part of Cha I detected 13 members near and below the hydrogen burning mass limit, which are known as Cha $H\alpha$ 1 through 13 (Comerón et al. 1999, 2000; Neuhäuser & Comerón 1999). Since their discovery, these objects have been popular targets for studies of young low-mass stars and brown dwarfs because of their relatively close proximity to the Sun and low extinction. For instance, Cha $H\alpha$ 1 was the first brown dwarf detected in X-rays (Neuhäuser & Comerón 1998) and several of the Cha $H\alpha$ sources have been used for studying Li abundances in young low-mass stars (Johnas et al. 2007). Comerón et al. (2004) performed a deep $H\alpha$ survey across all of Cha I and obtained spectra of candidates appearing therein and other candidates from the literature. In doing so, Comerón et al. (2004) identified 18 new members, 15 of which were independently found by Luhman (2004a, 2007).

4.2. Variability

Along with $H\alpha$ emission, photometric variability was an early indicator of the presence of young stars in Chamaeleon (Hoffmeister 1962). The deepest variability survey in Chamaeleon was performed by Carpenter et al. (2002). They conducted near-IR monitoring of a $0.72^\circ \times 6^\circ$ strip in Cha I using the southern telescope of the Two-Micron All-Sky Survey (2MASS, Skrutskie et al. 2006). In these data, Carpenter et al. (2002) discovered 10 objects that exhibited variability or K -band excess emission that were suggestive of youth and membership in the star-forming region. Nine of these sources were observed spectroscopically by Luhman (2004a); seven candidates were confirmed as members while the others were classified as background sources. One of these confirmed members, CHSM 17173, has a spectral type of M8, making it the coolest and least massive known member of Cha I at that time.

4.3. X-rays

Since the 1980's, X-ray satellites have been heavily employed in searching for new members of Chamaeleon. Feigelson & Kriss (1989) obtained X-ray images of most of Cha I with the *Einstein Observatory* and Walter (1992) performed spectroscopy on some of the resulting candidates. Feigelson et al. (1993) detected more candidate members of Cha I with the *Röntgen Satellite (ROSAT)*, which were observed spectroscopically by Huenemoerder et al. (1994) and Lawson et al. (1996). Similar observations have been performed toward Cha II with *ASCA* (Yamauchi et al. 1998) and *ROSAT* (Alcalá et al. 2000). Alcalá et al. (1995, 1997) and Covino et al. (1997a) used the *ROSAT* all-sky survey to identify candidate young stars across the entire Chamaeleon complex and obtained followup optical spectroscopy for these objects. The deepest X-ray observations of Chamaeleon have been performed with *XMM-Newton* and the *Chandra X-ray Observatory*. In an exposure with *XMM* of a $27' \times 27'$ field in the southern cluster in Cha I, Stelzer et al. (2004) detected 38 of the 72 known members that were within the field of view. In the northern cluster in Cha I, Feigelson & Lawson (2004) observed a $16' \times 16'$ field with *Chandra*, detecting 27 previously known members. Feigelson & Lawson (2004) found no new candidate members, and concluded that the known membership in their survey field is complete to $\sim 0.1 M_\odot$. The membership classifications based on the X-ray data from Feigelson & Lawson (2004) agreed well with the classifications by Luhman (2004a) using other diagnostics. Robrade & Schmitt (2007) obtained a deep *XMM* image centered on the young star T49 in Cha I, detecting 17 of the 23 known members within the field of view. The boundaries of the *Chandra* and *XMM* fields and the distributions of spectral types for all known members of Cha I within them are shown in Figures 6 and 7, respectively. The coolest known members of Cha I detected in X-rays are Cha $H\alpha$ 1, Cha $H\alpha$ 7, CHSM 17173, and 2MASS J11011926–7732383B (Neuhäuser & Comerón 1998; Stelzer et al. 2004; Stelzer & Micela 2007; Robrade & Schmitt 2007), which have spectral types of M7.75 to M8.25.

4.4. Optical and Near Infrared

Because of the modest extinction of most of the Chamaeleon clouds ($A_V < 5$), many of its members can be identified with optical color-magnitude diagrams. López Martí et al. (2004, 2005) and Spezzi et al. (2007) obtained images in $H\alpha$ and broad- and intermediate-band optical filters for most of the Cha I and II clouds. With these data,

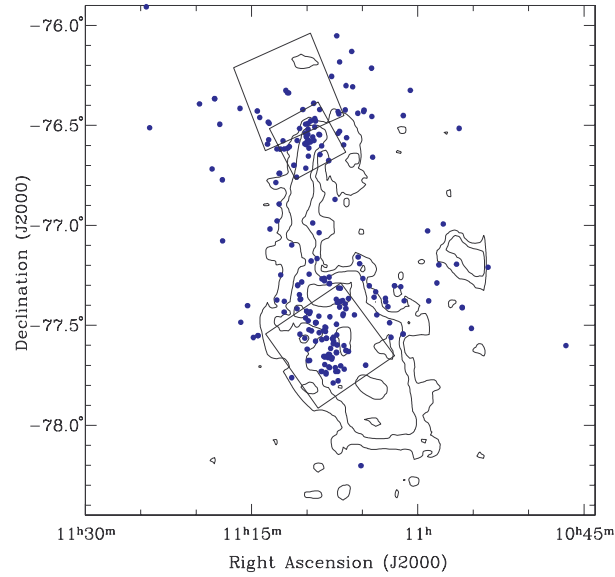


Figure 6. Boundaries of X-ray images from *Chandra* (middle box, Feigelson & Lawson 2004) and *XMM* (bottom and top boxes, Stelzer et al. 2004; Robrade & Schmitt 2007) shown with known members of Cha I (points). The contours represent the extinction map of Cambr  sy et al. (1997) at intervals of $A_J = 0.5, 1$, and 2 .

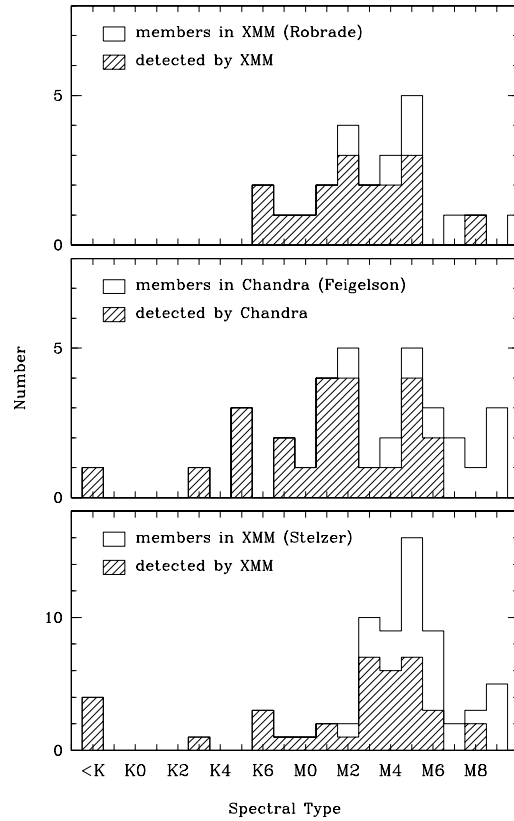


Figure 7. Distributions of spectral types for members of Cha I within the X-ray images and the ones that are detected (open and shaded histograms).

they identified candidate low-mass members and estimated their spectral types from the narrowband photometry. Spectral classifications of the candidates from López Martí et al. (2004) are summarized by Luhman (2007). Luhman (2007) performed a wide-field search for members of Cha I using data from 2MASS and the Deep Near-Infrared Survey of the Southern Sky (DENIS) and conducted deeper searches in smaller fields using broad-band optical imaging from Magellan Observatory and the *Hubble Space Telescope*. The candidates from these observations were then observed spectroscopically, resulting in the confirmation of 50 young stars and brown dwarfs.

Near-IR imaging surveys have been used to search for new members of Chamaeleon by identifying objects with K -band excess emission indicative of circumstellar disks. In the earliest study of this kind in Chamaeleon, Hyland et al. (1982) and Jones et al. (1985) performed K -band scans of a relatively large area in Cha I (1400 arcmin^2) and obtained followup JHK photometry and optical spectroscopy for some of the detected sources to assess their membership. Using iJK_s photometry from DENIS, Cambrésy et al. (1998) found 54 candidate members in a $1.5^\circ \times 3^\circ$ field in Cha I. Based on spectroscopy and color-magnitude diagrams of these candidates, Luhman (2004a) classified 10 as members and 27 as field stars, while the remaining candidates could not be classified with available data. Using methods similar to those of Cambrésy et al. (1998), Vuong et al. (2001) produced a list of 70 candidate low-mass members of Cha II. Barrado y Navascués et al. (2004) performed spectroscopy on 20 of these candidates and confirmed only one as a member, which they classified as M5.5. This spectral type corresponds to a mass of $\sim 0.15 M_\odot$ with the evolutionary models of Chabrier et al. (2000) and Baraffe et al. (1998), placing it near the peak of the stellar initial mass function (§ 4.6.). By obtaining JHK images of 1 deg^2 in Cha I, Gómez & Kenyon (2001) identified 100 candidate members that exhibited K -band excess emission. However, in the near-IR survey by Carpenter et al. (2002), few of these candidates showed excesses. In an attempt to find members at substellar masses, Tamura et al. (1998) and Oasa, Tamura, & Sugitani (1999) obtained deeper JHK images of a smaller field ($5' \times 5'$) in the northern cluster of Cha I. One of the resulting candidate brown dwarfs, OTS 44, has been spectroscopically confirmed as a member and classified as M9.5 (Luhman et al. 2004; Luhman 2007) while another candidate, OTS 32, is a low-mass star that may have an edge-on disk (Luhman & Muench 2008). In the deepest near-IR observations to date in Cha I, Comerón & Claes (2004) used the European Southern Observatory's Very Large Telescope to collect JHK images of a $2.5' \times 2.5'$ field. With these near-IR data, they identified a candidate brown dwarf at $H \sim 22$, which would correspond to a mass below that of Jupiter for a bona fide member. Comerón & Claes (2004) obtained a low-resolution IR spectrum of the candidate, but they could not conclusively classify the object as either a member or a background source.

4.5. Mid and Far Infrared

Compared to near-IR photometry, data at mid- and far-IR wavelengths are much more sensitive to excess emission from circumstellar material. Data of this kind are particularly useful for detecting the youngest, most embedded members of a star-forming region. Mid- and far-IR searches for new members have been performed with the *Infrared Astronomical Satellite (IRAS)* for large fractions of Cha I and II (Baud et al. 1984; Whittet et al. 1991a; Prusti et al. 1992a; Larson et al. 1998) and for smaller fields around Ced 110, 111, and 112 (Assendorp et al. 1990; Prusti et al. 1991). Similar surveys were later conducted with the *Infrared Space Observatory (ISO)*, Nordh et al. 1996;

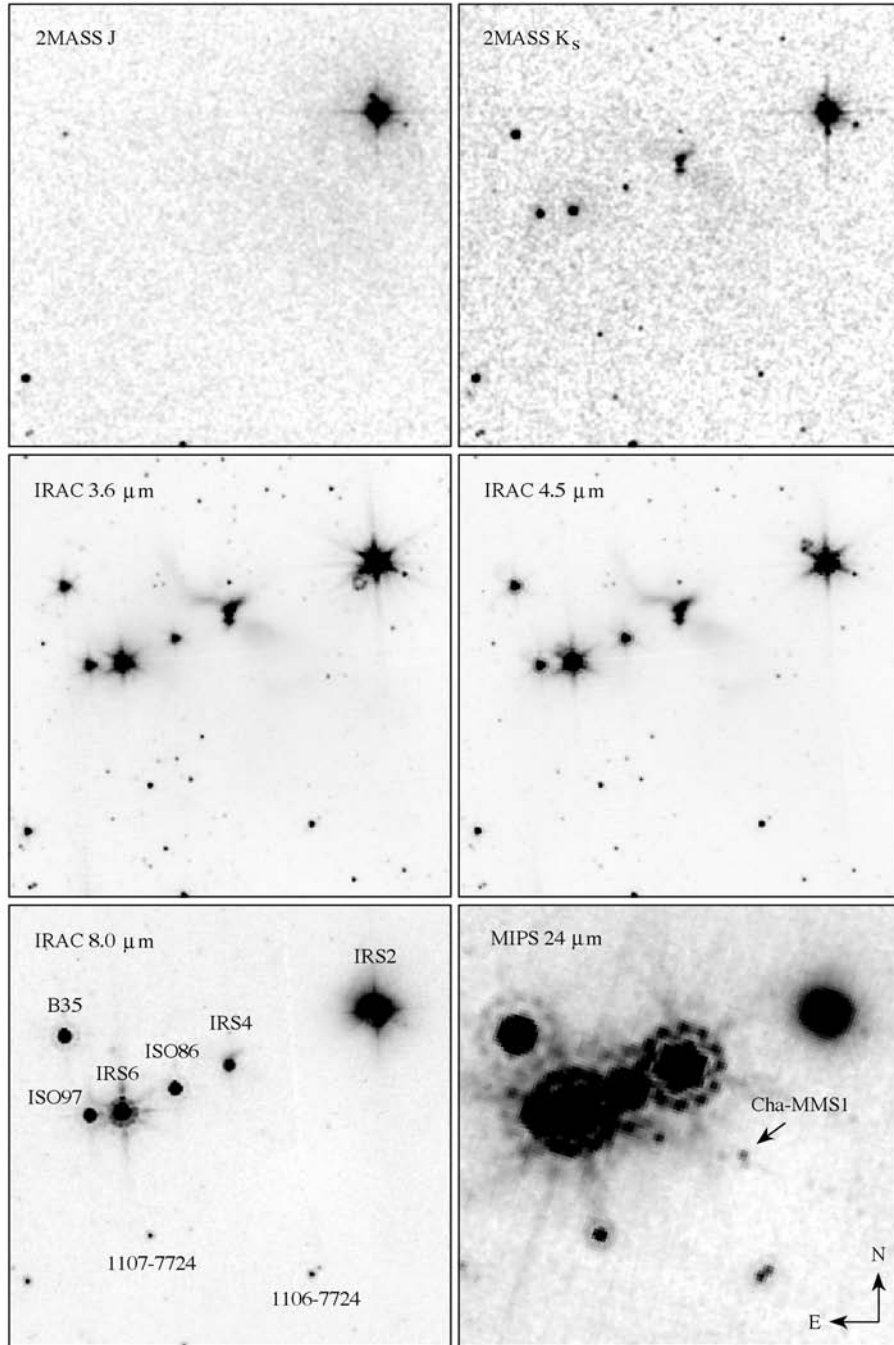


Figure 8. Near- and mid-IR images of the region surrounding the Ced 110 reflection nebula in Cha I ($5' \times 5'$, Luhman et al. 2008). All known members of Cha I within this area are labeled. 2MASS J11062942–7724586, 2MASS J11070369–7724307, 2MASS 1106–7724 and 2MASS 1107–7724 are highly reddened, low-mass disk-bearing sources. A redder and fainter candidate member of Cha I appears $7''$ northwest of 2MASS J11062942–7724586. The protostar Cha-MMS1 (Reipurth et al. 1996) is detected at $24 \mu\text{m}$. The faint source in the middle of the $24 \mu\text{m}$ image (southeast of Ced 110-IRS4) is a latent image from Ced 110-IRS6.

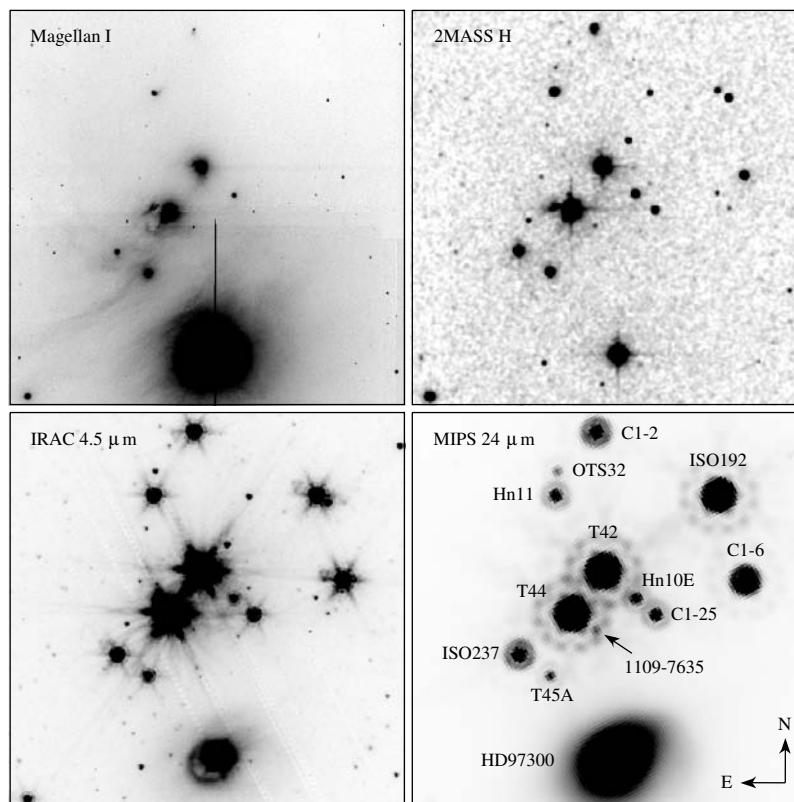


Figure 9. Optical and IR images of the region surrounding the Ced 112 reflection nebula in Cha I ($5' \times 5'$, Luhman & Muench 2008). All known members of Cha I within this area are labeled. OTS 32 is a low-mass star that may have an edge-on disk. 2MASS J11095493–7635101 is one of the least massive known Class I sources.

Persi et al. 1999, 2000, 2003; Lehtinen et al. 2001), which provided greater sensitivity and higher spatial resolution than *IRAS*. By combining images at 6.7 and 14.3 μm from *ISO* with near-IR data from DENIS, Persi et al. (2000) reported the discovery of 34 new young stars in Cha I. Through spectroscopy, Luhman (2004a) confirmed the membership of eighteen of these stars and found that 10 others were field stars. In Cha II, Alcalá et al. (2006) used data from *ISO* to identify a candidate low-mass object, which they spectroscopically confirmed as a member. The newest IR satellite, the *Spitzer Space Telescope*, also has been used to map the Chamaeleon clouds. Young et al. (2005) and Porras et al. (2007) obtained *Spitzer* images of Cha II between 3.6 and 160 μm . Even with the unprecedented sensitivity of these data, only a few new young stars were discovered. Using a combination of *IJK* photometry from ground-based telescopes and mid-IR measurements from *Spitzer*, Allers et al. (2006, 2007) searched for young brown dwarfs with disks in Cha II and other star-forming regions. Through this work, they recovered the object found by Alcalá et al. (2006) with *ISO* and discovered two additional substellar members of Cha II. Similarly, Luhman et al. (2005c, 2008) and Luhman & Muench (2008) used deep *Spitzer* images of Cha I to find new stars and brown dwarfs with disks, including the least massive known Class II and Class I members of the cluster and possible edge-on disks. Some of these new members are within

the ground-based and *Spitzer* images of Ced 110 and Ced 112 in Figures 8 and 9. The survey of Luhman et al. (2008) demonstrated that the current census of disk-bearing members of Cha I is nearly complete at stellar masses except for close companions and Class 0 sources, while the completeness at substellar masses is uncertain because of contamination by faint red galaxies.

4.6. Current Census

Although a large number of surveys for young stars have been performed in Chamaeleon, many of the objects that have been referred to as members lack either conclusive evidence of membership or accurate spectral classifications. To refine the census of known members of Cha I, Luhman (2004a) obtained optical spectra of most of the objects that were previously identified as possible members of the cluster, that lacked either accurate spectral classifications or evidence of membership, and that were sufficiently bright ($I \lesssim 18$). Luhman (2004a) then used these spectroscopic data and other available constraints to evaluate the spectral classifications and membership status of the candidate members of Cha I that appeared in previous studies of the cluster. The resulting census contained 158 members. A likely member that was overlooked in that census is ESO H α 281 from Reipurth & Zinnecker (1993) and Brandner & Zinnecker (1997). Luhman (2004a) assigned membership to SGR 1 and ISO 13 based on the spectral type from Saffe et al. (2003) and a detection of mid-IR excess emission from Persi et al. (2000), respectively. However, they have been classified as a field star and a galaxy (Luhman 2007; Luhman et al. 2008). The census from Luhman (2007) did not include protostellar sources that have been detected only at far-IR wavelengths and longward, such as Cha-MMS1 (Reipurth et al. 1996). Because this source has been detected at 24 μ m (Belloche et al. 2006; Luhman et al. 2008), it is included in the list of members in this review. Since the census of Luhman (2004a), 78 additional members have been identified by Comerón et al. (2004), Luhman (2004b, 2007), Luhman et al. (2004, 2005c, 2006, 2008), and Luhman & Muench (2008). Luhman (2007) also spectroscopically confirmed the membership of two candidate companions, T3B and T39B. Three young stars from Covino et al. (1997a) share the same proper motion as Cha I, and thus are adopted as members of Cha I Luhman et al. (2008). Meanwhile, four young stars from Luhman (2007), 2MASS J11183572–7935548, J11334926–7618399, J11404967–7459394, and J11432669–7804454, are not counted as members because their proper motions suggest membership in ϵ Cha association rather than the Cha I cloud (Luhman et al. 2008). The resulting census of Cha I contains 237 sources and is compiled in Tables 1 and 2. Table 1 lists the various identifications that have been used for each member, which is an updated version of the compilation of source names from Carpenter et al. (2002). Table 2 provides all available spectral type measurements and evidence of membership. The latter consists of $A_V \gtrsim 1$ and a position above the main sequence for the distance of Cha I (A_V), strong emission lines (e), Na I and K I strengths intermediate between those of dwarfs and giants (NaK), strong Li absorption (Li), IR excess emission (ex), the shape of the gravity-sensitive steam bands (H₂O), or a proper motion (μ), parallax (π), or radial velocity (rv) that is similar to that of the known members of Cha I (Luhman 2004a, 2007). The positions of the known members of Cha I are plotted with the extinction map from Cambrésy et al. (1997) in Figure 10.

The most recent estimates of extinctions, luminosities, and effective temperatures for members of Cha I are provided by Luhman (2007), Luhman et al. (2008), and Luhman & Muench (2008). The Hertzsprung-Russell (H-R) diagram for the cluster is

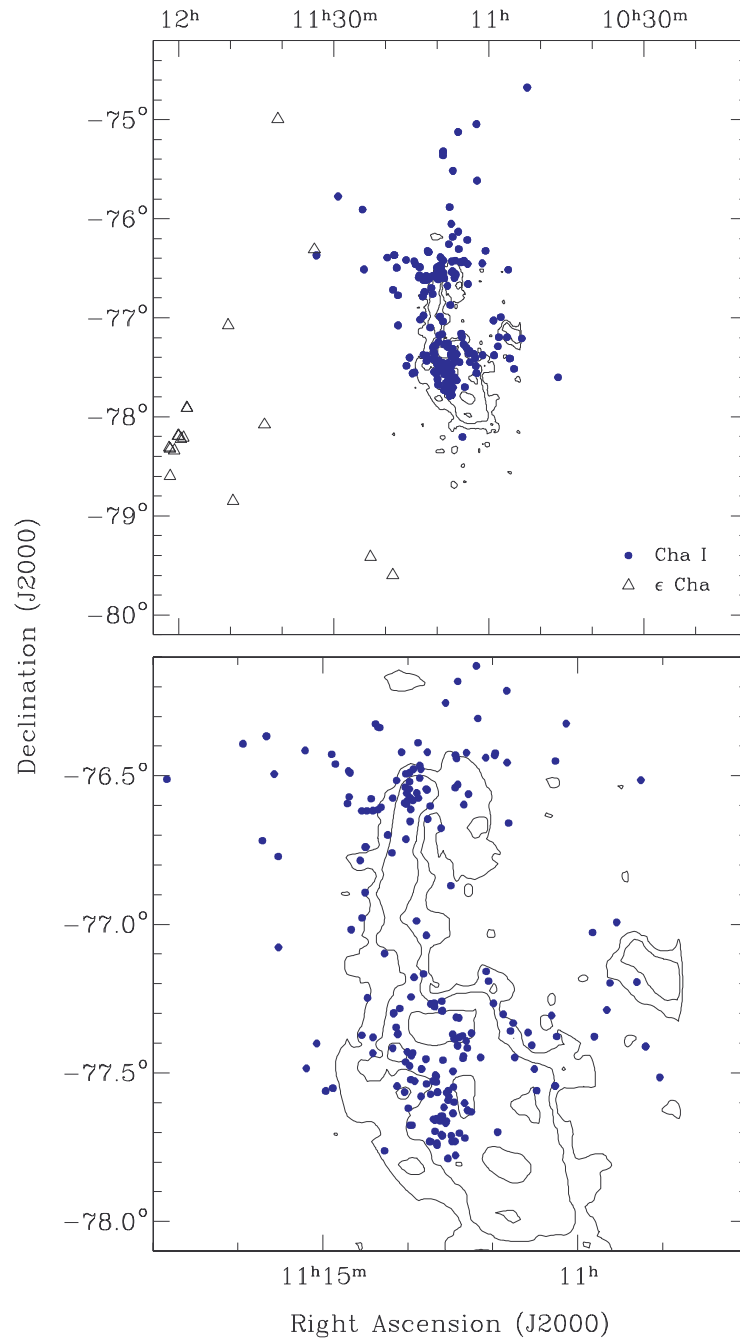


Figure 10. Spatial distribution of known members of Cha I (*points*, Luhman 2007; Luhman et al. 2008). Probable members of the ϵ Cha young association are indicated (*open triangles*, Covino et al. 1997a; Feigelson et al. 2003; Luhman 2004c; Luhman et al. 2008). The contours represent the extinction map of Cambr  sy et al. (1997) at intervals of $A_J = 0.5, 1, \text{ and } 2$.

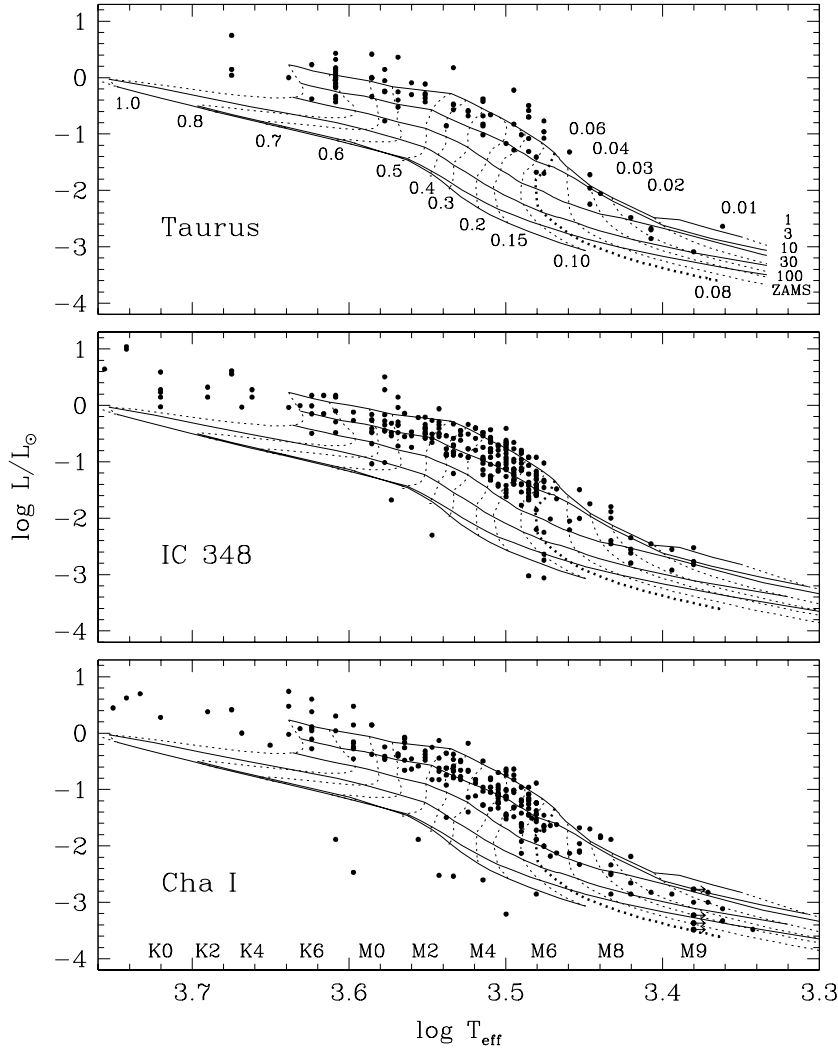


Figure 11. H-R diagrams of Cha I (Luhman 2007; Luhman et al. 2008; Luhman & Muench 2008), IC 348 (Luhman et al. 2003b), and Taurus (Briceño et al. 2002; Luhman et al. 2003a) shown with the theoretical evolutionary models of Baraffe et al. (1998, $0.1 < M/M_{\odot} \leq 1$) and Chabrier et al. (2000, $M/M_{\odot} \leq 0.1$), where the mass tracks (*dotted lines*) and isochrones (*solid lines*) are labeled in units of $M_{\odot}$ and Myr, respectively.

shown in Figure 11. For comparison, H-R diagrams for IC 348 and Taurus are also included (Briceño et al. 2002; Luhman et al. 2003a,b). According to the evolutionary models of Baraffe et al. (1998) and Chabrier et al. (2000), Cha I has a median age of ~ 2 Myr, which is similar to that for IC 348 and slightly greater than the age of ~ 1 Myr for Taurus. The distribution of isochronal ages suggests that star formation began 3-4 and 5-6 Myr ago in the southern and northern subclusters, respectively, and has continued to the present time at a declining rate (Luhman 2007). The combination

Table 1.: Known Members of Chamaeleon I: Names

2MASS	Names
J10463795 – 7736035	HD93828
J10523694 – 7440287	...
J10533978 – 7712338	...
J10550964 – 7730540	ESOH α 552
...	T3B
J10555973 – 7724399	T3A, Cam1-3, SXCha, Sz2, S6320, HM1, HBC564, B1, 10548 – 7708
J10561638 – 7630530	ESOH α 553
J10563044 – 7711393	T4, Cam1-4, SYCha, Sz3, S6321, HM2, CHXR1, CHX1, HBC565, B2, 10552 – 7655
J10574219 – 7659356	T5, Cam1-5, Sz4
J10580597 – 7711501	...
J10581677 – 7711710	T6, Cam1-7, SZCha, S6323, CHXR4, CHX2, HBC566, B4, 10570 – 7701, Glass V
J10590108 – 7722407	T7, Cam1-8, TWCha, Sz5, S6326, HM3, CHXR5, HBC567, B5, 10577 – 7706
J10590699 – 7701404	T8, Cam1-9, CRCCha, Sz6, HM4, CHXR6, CHX3, HBC244, B6, 10578 – 7645, LkH α 332-20
J11004022 – 7619280	T10, Cam1-12, Sz8, HM6
J11011370 – 7722387	...
J11011875 – 7627025	CHXR9C, Cam1-13
J11011926 – 7732383A	...
J11011926 – 7732383B	...
J11013205 – 7718249	ESOH α 554
J11020610 – 7718079	...
J11021927 – 7536576	...
J11022491 – 7733357	T11, Cam1-15, CSCCha, Sz9, HM7, CHXR10, CHX4, HBC569, ISO3, B10, 11011 – 7717
J11022610 – 7502407	...
J11023265 – 7729129	CHXR71, Cam1-16, Hn1, ISO4, B11, [LES2004]453
J11024183 – 7724245	[LES2004]423
J11025374 – 7722561	[LES2004]424
J11025504 – 7721508	T12, Cam1-17, Sz10, HM8, [LES2004]456
J11034186 – 7726520	ISO28, CHSM757, [LES2004]422
J11034764 – 7719563	Hn2, CHSM1012, Cam1-19, ISO32, B13a, [LES2004]425
J11035682 – 7721329	CHXR12, CHSM1403, Cam1-21, Hn3, ISO34, B14
J11040425 – 7639328	CHSM1715, ESOH α 557
J11040909 – 7627193	T14, CHSM1898, Cam1-22, CTCha, Sz11, HM9, CHXR13, HBC570, 11027 – 7611
J11041060 – 7612490	CHSM1982

Table 1.: Known Members of Chamaeleon I: Names (continued)

2MASS	Names
J11042275–7718080	T14a, CHSM2482, Cam1-24, ISO46, 11030–7702, HH48
J11044258–7741571	ISO52, CHSM3319, Cam1-26, B18, [SMN2004]2, ESOHa α 558, [LES2004]457
J11045100–7625240	CHXR14N, CHSM3657, Cam1-27
J11045285–7625514	CHXR14S, CHSM3716, Cam1-28
J11045701–7715569	T16, CHSM3876, Cam1-29, Sz13, ISO55, B19, [LES2004]603
J11050752–7812063	...
J11051467–7711290	Hn4, CHSM4629, Cam1-30, [LES2004]622
J11052272–7709290	...
J11052472–7626209	...
J11054300–7726517	CHXR15, CHSM5856, Cam1-34, ISO65, B22, [SMN2004]6, [LES2004]449
J11055261–7618255	T20, CHSM6267, Cam1-35, UVCha, S6336, CHXR18, HBC571
J11055780–7607488	HD96675
J11060010–7507252	...
J11061540–7721567	T21, CHSM7184, Cam1-36, CHXR19, CHX7, ISO75, 11048–7706, Ced110-IRS2, GlassF, [SMN2004]8
J11061545–7737501	Cam2-19, [SMN2004]7, [LES2004]432
J11062554–7633418	ESOH α 559
...	CHXR73B
...	ChaJ11062854–7618039
J11062877–7737331	CHXR73A, CHSM7730, ISO78, B25, [SMN2004]9, [LES2004]433
J11062942–7724586	...
J11063276–7625210	CHSM7869, [LES2004]712
...	Cha-MMS1
J11063799–7743090	ChaH α 12, CHSM8077
J11063945–7736052	ISO79, CHSM8134, GK13
J11064180–7635489	Hn5, CHSM8234, Cam1-37, [LES2004]751
J11064346–7726343	T22, CHSM8284, Cam1-38, UXCha, S6337, ISO80, [SMN2004]10, [LES2004]450
J11064510–7727023	CHXR20, CHSM8369, Cam1-39, CHX8, ISO81, B26, Ced110-IRS3, [SMN2004]11
J11064658–7722325	Ced110-IRS4, CHSM8415, Cam1-40, ISO84, 11051–7706
J11065733–7742106	CHXR74, CHSM8892, ISO87, B27, [SMN2004]12
J11065803–7722488	ISO86, CHSM8924, Ced110-IRS11
J11065906–7718535	T23, CHSM8978, Cam1-41, UYCha, Sz16, S6340, HM11, ISO89, Ced110-IRS5, [LES2004]452
J11065939–7530559	...
J11070324–7610565	...

Table 1.: Known Members of Chamaeleon I: Names (continued)

2MASS	Names
...	ESOHa281
J11070369–7724307	...
...	ChaJ11070768–7626326
J11070919–7723049	Ced110-IRS6, CHSM9387, Cam1-42, ISO92, 11057–7706
J11070925–7718471	ISO91, CHSM9391, Cam2-21
J11071148–7746394	CHXR21, CHSM9467, Cam1-44, Hn6, ISO94, KG1, B28, [SMN2004]13
J11071181–7625501	CHSM9484, [LES2004]711
J11071206–7632232	T24, CHSM9496, Cam1-45, UZCha, Sz17, S6341, CHXR75
J11071330–7743498	CHXR22E, CHSM9542, Cam1-46, KG2, B29, [SMN2004]115
J11071622–7723068	ISO97, CHSM9652, Cam2-23, KG3
J11071668–7735532	ChaH α 1, CHSM9671, ISO95, [SMN2004]17
J11071860–7732516	ChaH α 9, CHSM9753, ISO98
J11071915–7603048	T25, CHSM9782, Cam1-47, Sz18, HM12, HBC572, 11057–7546
J11072022–7738111	...
J11072040–7729403	ISO99, [SMN2004]19, [LES2004]448
J11072074–7738073	T26, CHSM9847, Cam1-48, DiCha, Sz19, HM13, CHXR23, CHX9, HBC245, ISO100, KG6, B32, 11059–7721, Ced111-IRS1, LkH α 332-1, [SMN2004]20
J11072142–7722117	B35, CHSM9872, Cam2-24, ISO101, KG7
J11072443–7743489	[LES2004]429
...	ChaJ11072647–7742408
J11072825–7652118	T27, CHSM10138, Cam1-49, VVCha, Sz20, S6342, HM14, CHXR24, HBC573, KG12
J11073519–7734493	CHXR76, CHSM10394, Cam1-51, ISO106, KG15, B34, [SMN2004]22
J11073686–7733335	CHXR26, CHSM10464, Cam1-52, ISO108, KG17, B35, [SMN2004]23
J11073775–7735308	ChaH α 7, CHSM10496, [SMN2004]25
J11073832–7747168	[SMN2004]24, ESOH α 560
J11073840–7552519	...
J11074245–7733593	ChaH α 2, CHSM10685, ISO111, KG20, [SMN2004]26
J11074366–7739411	T28, CHSM10737, Cam1-53, Sz21, HM15, CHXR27, HBC574, ISO112, KG21, B36, [SMN2004]27
J11074610–7740089	ChaH α 8, CHSM10837, [SMN2004]28
J11074656–7615174	CHSM10862
J11075225–7736569	ChaH α 3, CHSM11114, ISO116, KG23, [SMN2004]29
J11075588–7727257	CHXR28, CHSM11256, Cam1-54, CHX10a, ISO117, KG24, B37, [SMN2004]30
J11075730–7717262	CHXR30B, CHSM11315, Cam1-55, KG26, B38b, 11065–7701, Ced110-IRS7, [LES2004]609

Table 1.: Known Members of Chamaeleon I: Names (continued)

2MASS	Names
J11075792 – 7738449	T29, CHSM11344, Cam1-56, Sz22, HM16, ISO119, KG28, B39, [SMN2004]31
J11075809 – 7742413	T30, CHSM11351, Cam1-57, Sz23, ISO120, KG27
J11075993 – 7715317	ESOHa α 561, [LES2004]610
J11080002 – 7717304	CHXR30A, CHSM11416, Cam1-58, ISO122, KG30, B38a, [LES2004]608
J11080148 – 7742288	T31, CHSM11462, Cam1-59, VWCha, Sz24, S6343, HM17, CHXR31, CHX11, HBC575, ISO123, KG31, B40, Ced111-IRS3, [SMN2004]32
J11080234 – 7640343	[LES2004]717
J11080297 – 7738425	ISO126, CHSM11529, Cam2-32, KG33, [SMN2004]33, ESOHa α 562
J11080329 – 7739174	T32, CHSM11547, Cam1-60, CUCha, Sz25, HM18, CHXR29, HBC246, ISO124, KG34, 11066 – 7722, Ced111-IRS2, HD97048, [SMN2004]34
J11080609 – 7739406	...
...	T33B
J11081509 – 7733531	T33A, CHSM12055, Cam1-61, CHXR32, CHX12, ISO135, KG39, B42, 11068 – 7717, Ced111-IRS4, GlassI, [SMN2004]37
J11081648 – 7744371	T34, CHSM12090, Cam1-62, Sz26, HM19, ISO136, KG40, B44, [SMN2004]38
J11081703 – 7744118	ChaH α 13, CHSM12108, ISO137, KG41, [SMN2004]39
J11081850 – 7730408	ISO138, CHSM12159, [LES2004]410
J11081896 – 7739170	ChaH α 4, CHSM12180, [SMN2004]40
...	ChaJ11081938 – 7731522
J11082238 – 7730277	ISO143, CHSM12355, KG45, [LES2004]411
J11082404 – 7739299	ChaH α 10, CHSM12438
J11082410 – 7741473	ChaH α 5, CHSM12442, ISO144, KG47, [SMN2004]41
J11082570 – 7716396	...
J11082650 – 7715550	ISO147, CHSM12525, [LES2004]613
J11082927 – 7739198	ChaH α 11, CHSM12653
...	ChaJ11083040 – 7731387
J11083896 – 7743513	IRN, CHSM13053, Cam1-63, ISO150, KG49, 11072 – 7727, Ced111-IRS5
J11083905 – 7716042	T35, CHSM13058, Cam1-64, Sz27, HM20, C6-1, HBC576, ISO151, KG50, Ced110-IRS8
J11083952 – 7734166	ChaH α 6, CHSM13082, ISO152, KG51, [SMN2004]43
J11084069 – 7636078	CHXR33, CHSM13131, Cam1-65, CHX13a, C1-10, ISO153, KG52, [FL2004]8, [LES2004]752
J11084296 – 7743500	...
J11084952 – 7638443	...
J11085090 – 7625135	T37, CHSM13553, Cam1-68, Sz28, ISO157, KG54, [FL2004]15, [LES2004]709
J11085176 – 7632502	[LES2004]737

Table 1.: Known Members of Chamaeleon I: Names (continued)

2MASS	Names
J11085242–7519027	RX J1108.8–7519B
J11085326–7519374	RX J1108.8–7519A
J11085367–7521359	...
J11085421–7732115	CHXR78C, CHSM13696, Cam1–69, ISO160, KG56, B45, [SMN2004]45
J11085464–7702129	T38, CHSM13707, Cam1–70, VYCha, Sz29, S6346, HM21, C4–5, HBC577, ISO162, KG58
J11085497–7632410	ISO165, CHSM13720, KG59, ESOH α 564, [LES2004]735
J11085596–7727132	ISO167
J11090512–7709580	Hn7, CHSM14124, Cam1–71, ISO174, [LES2004]615
J11091172–7729124	T39A, CHSM14388, Cam1–72, Sz30, CHXR36, CHX14, C7–7, ISO182, KG74, B46, [SMN2004]47
...	T39B
J11091297–7729115	...
...	ChaJ11091363–7734446
J11091380–7628396	CHXR35, CHSM14469, Cam1–73, Hn8, C1–15, KG75, [FL2004]25, [LES2004]708, [RS2007]4
J11091769–7627578	CHXR37, CHSM14604, Cam1–74, ISO185, KG77, [FL2004]26, [RS2007]5
J11091812–7630292	CHXR79, CHSM14623, Cam1–75, Hn9, C1–18, ISO186, KG79, [FL2004]27, [RS2007]6
J11092266–7634320	C1–6, CHSM14800, Cam1–76, ISO189, KG82, OTS10, Ced112–IRS2, [FL2004]29, [LES2004]731
J11092379–7623207	T40, CHSM14843, Cam1–77, VZCha, Sz31, S6347, HM22, CHXR39, HBC578, KG83, 11078–7607, Ced112–IRS1, [RS2007]7
J11092855–7633281	ISO192, CHSM15044, Cam2–41, KG87, OTS15, [FL2004]33
J11092913–7659180	[LES2004]602
J11093543–7731390	...
J11093777–7710410	Cam2–42
J11094006–7628391	CHXR40, CHSM15504, Cam1–78, CHX15b, ISO198, KG92, [FL2004]38, [RS2007]9
J11094192–7634584	C1–25, CHSM15576, Cam1–79, ISO199, KG93, OTS19, [FL2004]41
J11094260–7725578	C7–1, CHSM15600, Cam1–80, ISO200, KG95, Ced110–IRS9, ESOH α 565, [LES2004]418
J11094525–7740332	[SMN2004]51, ESOH α 566, [LES2004]434
J11094621–7634463	Hn10E, CHSM15745, Cam1–82, T42, Sz32, HM23, C1–24, ISO204, KG97, OTS24, 11083–7618, Ced112–IRS4, [FL2004]43
J11094742–7726290	B43, CHSM15784, Cam1–84, ISO207, KG101, [SMN2004]52, ESOH α 567, [LES2004]417
J11094866–7714383	ISO209, CHSM15850, Cam2–45
J11094918–7731197	KG102
J11095003–7636476	T41, CHSM15900, Cam1–85, CHXR42, C1–11, ISO211, KG103, OTS26, 11082–7620, Ced112–IRS3, HD97300, [FL2004]44
J11095215–7639128	ISO217, CHSM15980, KG106, GK29, [FL2004]46, [LES2004]726
J11095262–7740348	CHSM15991
J11095336–7728365	ISO220, CHSM16023, GK30, [LES2004]412

Table 1.: Known Members of Chamaeleon I: Names (continued)

2MASS	Names
J11095340–7634255	T42, CHSM16026, Cam1-86, Sz32, HM23, C1-5, HBC579, ISO223, KG109, OTS27, 11083–7618, [FL2004]47, [LES2004]753
J11095407–7629253	T43, CHSM16052, Cam1-87, Sz33, CHXR41, CHX15, C1-17, ISO224, KG110, [FL2004]48, [RS2007]12
J11095437–7631113	ISO225, CHSM16067, GK31, [FL2004]49
J11095493–7635101	...
J11095505–7632409	C1-2, CHSM16096, Cam1-88, ISO226, KG111, OTS28, Ced112-IRS5, [FL2004]51
J11095873–7737088	T45, CHSM16254, Cam1-89, WXCha, Sz35, S6349, HM25, CHXR43, CHX17, C8-3, HBC581, ISO228, KG114, B48, 11085–7720, Ced111-IRS6, [SMN2004]54
J11100010–7634578	T44, CHSM16307, Cam1-90, WWCha, Sz34, S6348, HM24, CHXR44, C1-7, HBC580, ISO231, KG116, OTS29, [FL2004]53
J11100192–7725451	[LES2004]419
J11100336–7633111	OTS32
J11100369–7633291	Hn11, CHSM16436, Cam1-91, C1-4, ISO232, KG117, OTS33, [FL2004]55
J11100469–7635452	T45a, CHSM16470, Cam1-92, CHXR45, CHX16, C1-9, HBC582, ISO233, KG118, OTS35, GK-1, [FL2004]56
J11100658–7642486	...
J11100704–7629376	T46, CHSM16560, Cam1-93, WYCha, Sz36, S6351, HM26, CHXR46, C1-16, HBC583, ISO234, KG119, 11085–7613, Ced112-IRS6, [FL2004]58, [RS2007]113
J11100785–7727480	ISO235, CHSM16611, KG120
J11100934–7632178	OTS44, CHSM16658
J11101141–7635292	ISO237, CHSM16751, Cam2-48, C1-8, KG121, OTS45, [FL2004]61, [LES2004]760
J11101153–7733521	...
J11102226–7625138	CHSM17173, [LES2004]710, [RS2007]116
J11102852–7716596	Hn12W, CHSM17417, Cam1-94, C6-2, ISO244, [LES2004]625
J11103481–7722053	[LES2004]405
J11103644–7722131	ISO250, CHSM17743, [LES2004]404
J11103801–7732399	CHXR47, CHSM17807, Cam1-96, F34, C7-11, ISO251, KG124, B50, 11091–7716, Ced111-IRS7, GlassQ, [SMN2004]55
J11104006–7630547	...
J11104141–7720480	ISO252, CHSM17959, [LES2004]406
J11104959–7717517	T47, CHSM18261, Cam1-97, Sz37, HM27, HBC584, ISO254, 11093–7701
J11105076–7718031	ESOHa α 568, [LES2004]408
J11105333–7634319	T48, CHSM18403, Cam1-98, WZCha, Sz38, S6352, HM28, CHXR82, C1-23, HBC585, ISO258, [FL2004]74
J11105359–7725004	ISO256, CHSM18416, Cam2-49, [LES2004]403
J11105597–7645325	Hn13, CHSM18502, Cam1-99, C2-5, ISO259, [FL2004]75, [LES2004]755
J11111083–7641574	ESOHa α 569
J11112249–7745427	[LES2004]436

Table 1.: Known Members of Chamaeleon I: Names (continued)

2MASS	Names
J11112260–7705538	ISO274,[LES2004]629
J11113474–7636211	CHXR48,CHSM20217,Cam1-101,E1-7,ISO280,[FL2004]91
J11113965–7620152	T49,CHSM20409,Cam1-102,XXCha,Sz39,HM29,HBC586,11101–7603,[RS2007]35
J11114533–7636505	[LES2004]743
J11114632–7620092	CHX18N,CHSM20702,Cam1-103,11101–7603,[RS2007]37
J11115400–7619311	CHXR49NE,CHSM21078,Cam1-104,CHX18,Hn15,[RS2007]39
J11120288–7722483	...
J11120327–7637034	CHXR84,CHSM21466,Cam1-105,Hn16,E1-10,[FL2004]100,[LES2004]742
J11120351–7726009	ISO282,CHSM21473,ESOHa570,[LES2004]438
J11120984–7634366	T50,CHSM21745,Cam1-106,Sz40,CHXR85,E1-5,HBC587,[FL2004]103,[LES2004]757,[RS2007]44
J11122250–7714512	...
J11122441–7637064	T51,CHSM22361,Cam1-107,Sz41,CHXR50,CHX206,E1-9a,HBC588,11108–7620,Ced112-IRS7,[FL2004]105
J11122772–7644223	T52,CHSM22521,Cam1-108,CVCha,Sz42,HM30,CHXR51,CHX19,E2-4,HBC247,11108–7627,Ced112-IRS8,LkHa α 332-21
J11123092–7644241	T53,CHSM22662,Cam1-110,CWCha,Sz43,HM31,HBC589
J11123099–7653342	[LES2004]601
J11124210–7658400	CHXR54,CHSM23146,Cam1-111,CHX21a,E4-3
J11124268–7722230	T54,CHSM23172,Cam1-112,HMAnon,CHXR56,CHX22,B51,11111–7705
J11124299–7637049	CHXR55,CHSM23183,Cam1-113,CHX20E,E1-8
J11124861–7647066	Hn17,CHSM23447,Cam1-114,E2-9,[LES2004]754
J11132012–7701044	CHXR57,CHSM24835,Cam1-115,E4-4,B52
J11132446–7629227	Hn18,CHSM25026,Cam1-116,[LES2004]747,[RS2007]55
J11132737–7634165	CHXR59,CHSM25148,Cam1-117,E1-4,[RS2007]58
J11132970–7629012	CHXR60,CHSM25253,Cam1-118,Hn19,[LES2004]748,[RS2007]60
J11133356–7635374	T55,CHSM25420,Cam1-119,Sz44,CHXR61,E1-6,[LES2004]759
J11141565–7627364	CHXR62,CHSM27295,Cam1-120,Hn20,[RS2007]65
J11142454–7733062	Hn21W,CHSM27714,Cam1-121
J11142611–7733042	Hn21E,CHSM27789,Cam1-122
J11142906–7625399	ESOHa α 571,[RS2007]67
J11145031–7733390	B53,CHSM28885,Cam1-123
J11152180–7724042	ESOHa α 572
J11155827–7729046	...
J11160287–7624533	ESOHa α 574
J11173700–7704381	T56,Cam1-125,Sz45,HM32,CHXR66,HBC590,11159–7648

Table 1.: Known Members of Chamaeleon I: Names (continued)

2MASS	Names
J11173792–7646193	...
J11175211–7629392	...
J11181957–7622013	CHXR68B
J11182024–7621576	CHXR68A,Cam1-126
J11183379–7643041	...
J11194214–7623326	...
J11195652–7504529	...
J11241186–7630425	...
J11242980–7554237	...
J11291261–7546263	RX J1129.2–7546
J11332327–7622092	...

Table 2.: Known Members of Chamaeleon I: Spectral Types and Membership

Name	Spectral Type	References	Membership	References
2M J10463795–7736035	F0V	1	μ,π	2
2M J10523694–7440287	M4.75	3	NaK	3
2M J10533978–7712338	M2.75	4	A_V ,ex	4
2M J10550964–7730540	M5,M4.5	5,3	NaK	5,3
T3B	M3.5	3	NaK	3
2M J10555973–7724399	M1,M0.5,M0.5,K8-M0.5	6,7,8,3	e,ex,rv, A_V	(9,10,6,7,8,11,12,13,3),(14,15,16),17,3
2M J10561638–7630530	M5.6	3	NaK,e	3
2M J10563044–7711393	K2,M0:M0.5	18,8,19	e,ex,Li,rv	(9,10,18,6,7,8,12,19),(14,15,16),20,17
2M J10574219–7659356	M3.25	19	e,ex,rv,NaK	(10,12,19),15,21,19
2M J10580597–7711501	M5.25	3	NaK	3
2M J10581677–7717170	K0	7	e,ex	(7,22,12),(14,15,16,23,24)
2M J10590108–7722407	K0:M0:K8	6,8,19	e,ex,Li,rv, A_V	(9,10,18,6,7,8,12,19),(14,15,16),20,17,19
2M J10590699–7701404	G8,K0,K2,K2	9,18,7,8	e,ex,rv	(9,10,18,7,8,12,13),(14,15,16,23),21
2M J11004022–7619280	M3.75	19	e,NaK	(9,10,12,19),19
2M J11011370–7722387	M5.25	3	NaK	3
2M J11011875–7627025	M2.25	19	Li	25

Table 2.: Known Members of Chamaeleon I: Spectral Types and Membership (continued)

Name	Spectral Type	References	Membership	References
2M J11011926–7732383A	M7.25	26	NaK, A _v	26
2M J11011926–7732383B	M8.25	26	NaK	26
2M J11013205–7718249	M8.5, M8	5, 3	NaK	5, 3
2M J11020610–7718079	M8	4	e, NaK, ex	4
2M J11021927–7536576	M4.5	3	NaK	3
2M J11022491–7733357	K2, K2, K5, M0, K6	9, 18, 7, 8, 19	e, ex, Li, rv	(9, 10, 18, 7, 8, 11, 12, 19), (14, 15, 16, 23, 24), 20, 21
2M J11022610–7502407	M4.75	3	NaK	3
2M J11023265–7729129	M3	19	(A _v , Li), ex	19, 24
2M J11024183–7724245	M5	3	NaK, A _v	3
2M J11025374–7722561	M8.5	4	NaK, ex	4
2M J11025504–7721508	M0.5, M4.5	16, 19	e, ex, NaK	(9, 11, 16, 12, 27, 19), (16, 24), 19
2M J11034186–7726520	M5.5	19	NaK	19
2M J11034764–7719563	M5	19	NaK, A _v	19
2M J11035682–7721329	M4, M3.5	25, 19	Li, NaK	25, 19
2M J11040425–7639328	M4.25, M4.5	19, 5	(e, NaK, A _v), ex	(19, 5), 24
2M J11040909–7627193	K2, K7, K5	6, 8, 19	e, ex, Li, rv	(9, 18, 6, 7, 8, 12, 13, 19), (15, 16, 24), 20, (21, 17)
2M J11041060–7612490	M6	19	NaK	19
2M J11042275–7718080	K6–M0	19	e, ex	(12, 19), (15, 27, 24)
2M J11044258–7741571	M4, M4.5	19, 5	ex, NaK	(27, 24), (19, 5)
2M J11045100–7625240	K0–K3, K8	25, 19	Li	25
2M J11045285–7625514	F8–G5, M1.75	25, 19	Li	25
2M J11045701–7715569	M3	19	ex, A _v	(27, 24), 19
2M J11050752–7812063	M4.75	3	NaK	3
2M J11051467–7711290	M3.25	19	A _v , NaK	19
2M J11052272–7709290	M4.75	3	NaK, A _v	3
2M J11052472–7626209	M2.75	3	NaK	3
2M J11054300–7726517	M5.25	19	NaK	19
2M J11055261–7618255	M1.5	19	Li	19
2M J11055780–7607488	B6IV/V, B7V	1, 28	μ , π	2
2M J11060010–7507252	M4.5	3	NaK	3
2M J11061540–7721567	G3–G7	29	e, ex, rv	30, (31, 15, 32), 33
2M J11061545–7737501	M2, M2.75	34, 19	A _v	19
2M J11062554–7633418	M6, M5.25	5, 3	(NaK, e, A _v), ex	(5, 3), 24

Table 2.: Known Members of Chamaeleon I: Spectral Types and Membership (continued)

Name	Spectral Type	References	Membership	References
CHXR73B				
Cha J11062854–7618039	M9.5	35	H ₂ O, A _V	35
2M J11062877–7737331	M8-L0	4	e,NaK,ex	4
2M J11062942–7724586	M4.5; M3.25	36,19	A _V ,NaK	19
2M J11063276–7625210	M6	24	A _V ,H ₂ O,ex	24
Cha–MMS1				
2M J11063799–7743090	M6	19	(e,NaK),ex	19,24
	...	...	ex	37,32
2M J11063799–7743090	M7.5; M6.5	38,19	Li,rv,NaK	17,17,19
2M J11063945–7736052	M3,M5.25	39,19	ex,NaK,A _V	(27,24),19,19
2M J11064180–7635489	M4.5	19	e,NaK,ex	(12,19),19,24
2M J11064346–7726343	M3	19	Li,A _V	19
2M J11064510–7727023	K6	19	ex,Li,A _V	(14,31,27,24),(40,19),19
2M J11064658–7722325	...	...	ex	31,15,23,27,32,24
2M J11065733–7742106	M4.5,M4.25	36,19	Li,rv,NaK	(41,17),17,19
2M J11065803–7722488	...	...	ex	27,32,24
2M J11065906–7718535	M1.5,M4.25	16,3	e,ex,NaK	(9,10,16,12),(31,15,27,24),3
2M J11065939–7530559	M5.25	3	(e,NaK),ex	3,24
2M J11070324–7610565	M6	3	NaK	3
ESOHa281				
2M J11070369–7724307	M4.5	42	Li,ex	42,24
Cha J11070768–7626326	M7.5	24	A _V ,H ₂ O,ex	24
2M J11070919–7723049	L0	24	e,ex	24
2M J11070925–7718471	...	...	ex	43,31,15,27,32,24
2M J11071148–7746394	M2.5,M2-M4	34,3	ex	27,24
2M J11071181–7625501	M3	19	A _V ,NaK	19
2M J11071206–7632232	M5.25	19	(NaK,A _V),ex	19,24
2M J11071330–7743498	M0.5	19	e,ex,Li,A _V	(10,12,19),(15,16,24),19,19
2M J11071622–7723068	M3.5	19	(A _V ,NaK),ex	19,24
2M J11071622–7723068	M1	34	ex	27,24
2M J11071668–7735532	M7.5-M8,M7.5,M6-M7,M7.75	36,38,39,19	e,ex,NaK,Li,rv	36,(27,44),38,(41,17),17
2M J11071860–7732516	M5,M6,M5.5	39,38,19	e,ex,NaK,A _V	(39,38,19),(27,24),(38,19),19
2M J11071915–7603048	M2,M3,M2.5	7,8,19	Li,A _V	19
2M J11072022–7738111	M4.25	3	NaK,A _V	3
2M J11072040–7729403	M4.5	3	NaK	3
2M J11072074–7738073	G2,G2,G2.5,G2,G2	9,18,7,8,33	e,rv,ex	(9,10,18,7,8,12,33),(33,21),(14,45,15,16,23,27,24)

Table 2.: Known Members of Chamaeleon I: Spectral Types and Membership (continued)

Name	Spectral Type	References	Membership	References
2M J11072142–7722117	M2	34	ex.e	(27,24),34
2M J11072443–7743489	M5.75	3	NaK,Av	3
Cha J11072647–7742408	≥M9	3	H ₂ O	3
2M J11072825–7652118	K0+,M1,M1.5,M1.5+M3,M3	6,7,8,42,3	e,ex,rv,Li	(9,10,6,7,8,12,42,3),(15,16,24),21,42
2M J11073519–7734493	M5,M4.25	36,19	Li,rv,NaK,Av,ex	(41,17),17,19,19,24
2M J11073686–7733335	M3.5	19	NaK,Av	19
2M J11073775–7735308	M8,M7.75	38,19	NaK,Li,rv,e	(38,19),41,17,19
2M J11073832–7747168	M5,M4.5	5,3	NaK,Av	(5,3)
2M J11073840–7552519	M4.75	3	NaK	3
2M J11074245–7733593	M6,M6.5,M5,M5.25	36,38,39,19	e,ex,NaK,Li,rv,Av	(36,19),(27,24),(38,19),41,17,19
2M J11074366–7739411	M0.5,M0.5,M1,M0	7,16,36,3	e,ex,Av	(9,10,7,12,36,3),(14,15,27,24),3
2M J11074610–7740089	M6.5,M5.75	38,19	NaK,Li,rv	(38,19),(41,17),17
2M J11074656–7615174	M6.5,M5.75	34,19	NaK,ex	19,24
2M J11075225–7736569	M6,M7,M5.5	36,38,19	NaK,Li,rv,Av	(38,19),(41,17),17,19
2M J11075588–7727257	K7,K5	29,33	Li,rv	33
2M J11075730–7717262	M0.75–M1.75	19	ex.e,Av	(14,43,31,15,16,27,24),19,19
2M J11075792–7738449	K7,K4–K6	36,3	e,ex,Av	(9,10,12,36,3),(14,15,27,24),3
2M J11075809–7742413	M2.5,M2.5	36,3	e,Li,rv,Av,ex	(10,12,36,41,3),(41,17),17,3,24
2M J11075993–7715317	M6.5,M5.75	5,3	NaK,Av	(5,3),3
2M J11080002–7717304	K8	19	ex,Av	(14,43,31,15,16,27,24),19
2M J11080148–7742288	K2,K5–K7+K7,M0.5,K8	8,42,36,19	e, ex,Li,rv,Av	(9,10,18,6,7,8,11,12,42,36,13,19), (14,45,15,16,27,24),(20,42),17,19
2M J11080234–7640343	M6	3	NaK	3
2M J11080297–7738425	M2,M1.25,K:	34,19,5	ex.e,Av	(27,24),(46,19,5),19
2M J11080329–7739174	B9.5,B9.5,B9–A0	9,7,11	e,ex	(9,7,11,12,30),(15,16,23,27,24)
2M J11080609–7739406	≥M9	3	H ₂ O	3
T33B	K3,K7,K6	29,36,19	e,Li,Av	(29,19),19,19
2M J11081509–7733531	G3–G7,G3–K3	29,19	e,ex,Li,Av	(29,12,30,13,19),(14,45,15,16,23,27,24),(20,19),19
2M J11081648–7744371	M3.5,M3.75	16,19	NaK	19
2M J11081703–7744118	M5,M5.5	38,19	NaK	19
2M J11081850–7730408	M5.5,M6.5	39,19	ex.e,NaK	(27,44),39,19
2M J11081896–7739170	M6.5,M6,M5.5	36,38,19	NaK,Li,rv	(38,19),(41,17),17
Cha J11081938–7731522	M4.75	3	NaK,ex	3,24

Table 2.: Known Members of Chamaeleon I: Spectral Types and Membership (continued)

Name	Spectral Type	References	Membership	References
2M J11082238–7730277	M5.5,M5	39,19	ex,e,NaK,A _V	(27,24),(39,19),19,19
2M J11082404–7739299	M7.5,M6.25	38,19	NaK	38,19
2M J11082410–7741473	M6,M6,M5.5	36,38,19	NaK,Li,rv,A _V	(38,19),(41,17),17,19
2M J11082570–7716396	M8	3	NaK,ex	3,44
2M J11082650–7715550	M5.75	19	NaK,A _V ,ex	19,19,24
2M J11082927–7739198	M8,M7.25	38,19	NaK,ex	38,19,44
Cha J11083040–7731387	≥M9	3	H ₂ O	3
2M J11083896–7743513	<M0	19	ex	45,15,16,23,27,24
2M J11083905–7716042	M0,K8	16,19	e,ex,A _V	(9,10,16,12,19),(31,15,16,24),19
2M J11083952–7734166	M6,M7,M5.75	36,38,19	Li,NaK,rv,e,ex	(41,17),(38,19),17,19,24
2M J11084069–7636078	M0,M0,M2.5	29,25,3	Li,A _V	25,3
2M J11084296–7743500	M3-M5	24	A _V ,e,ex	24
2M J11084952–7638443	M8.75	3	e,NaK,ex	3,44
2M J11085090–7625135	M5.25	19	NaK,ex	19,24
2M J11085176–7632502	M7.25	3	NaK,A _V	3
2M J11085242–7519027	M2,M3	47,48	Li,μ,ex	48,24,24
2M J11085326–7519374	K6,K7	47,48	Li,μ	48,24
2M J11085367–7521359	M1.5	4	e,ex	4
2M J11085421–7732115	M5.5,M5.25	36,19	Li,NaK	41,19
2M J11085464–7702129	M0.5-,M0.5	8,19	e,ex,A _V	(9,10,8,11,12,19),(15,27,24),19
2M J11085497–7632410	M5.5,M6	19,5	(e,A _V ,NaK),ex	(19,5),24
2M J11085596–7727132	M5.25	3	NaK,A _V	3
2M J11090512–7709580	M4.75	19	NaK	19
2M J11091172–7729124	M0,M0.5+M2,M2	16,42,19	Li	42
T39B	M3	3	Li	3
2M J11091297–7729115	M3	4	NaK	4
Cha J11091363–7734446	M9.5	49,24	(H ₂ O,ex),NaK	49,24
2M J11091380–7628396	M4.75	19	NaK	19
2M J11091769–7627578	K7,K7,K7	47,48,3	Li,rv,A _V	(25,47,48),48,3
2M J11091812–7630292	M0.75-M1.75	19	e,ex,A _V	(12,19),(27,24),19
2M J11092266–7634320	M0.75-M1.75	19	ex,e,A _V	(45,15,27,24),19,19
2M J11092379–7623207	K6,K6	8,3	e,ex,Li,rv,A _V	(9,10,18,6,7,8,11,12,13,3),(45,15,16,24),20,17,3
2M J11092855–7633281	M6.5?	34	e,ex	34,24

Table 2.: Known Members of Chamaeleon I: Spectral Types and Membership (continued)

Name	Spectral Type	References	Membership	References
2M J11092913–7659180	M5.25	3	NaK, A _V	3
2M J11093543–7731390	M8.25	3	NaK	3
2M J11093777–7710410	M2, K7	34, 19	Li, A _V	19
2M J11094006–7628391	M1, M1.25	29, 19	Li, A _V	(25, 19), 19
2M J11094192–7634584	<M0	3	ex	27, 24
2M J11094260–7725578	M5, M6	19, 5	ex, e, NaK, A _V	(31, 15, 27, 24), (19, 5), (19, 5), (19, 5)
2M J11094525–7740332	M6.5, M5.75	5, 3	NaK, A _V	(5, 3)
2M J11094621–7634463	M3.25	19	e, ex, A _V , NaK	(9, 10, 12, 19), (27, 24), 19, 19
2M J11094742–7726290	M3.25, M1	19, 5	ex, e, A _V , NaK	(27, 24), (19, 5), (19, 5), 19
2M J11094866–7714383	M1	39	ex	27, 24
2M J11094918–7731197	M6, M5.5, M5.5	46, 19, 3	e, NaK	46, (46, 3)
2M J11095003–7636476	B9	7	e, A _V , ex	30, 7, (14, 45, 15, 16, 27)
2M J11095215–7639128	M6–M7	19	e, A _V , NaK, ex	19, 44
2M J11095262–7740348	M3	19	e, ex	19, 24
2M J11095336–7728365	M4.5, M5.5, M5.75	39, 46, 19	ex, e, NaK, A _V	(27, 24), (46, 19), (46, 19), 19
2M J11095340–7634255	K4–K6	19	e, ex, A _V	(12, 19), (15, 16, 23, 27, 24), 19
2M J11095407–7629253	M0, M2, M2	39, 46, 19	e, ex, A _V	(10, 12, 39, 46, 19), (27, 24), 19
2M J11095437–7631113	M2, M3, M1.75	39, 46, 19	ex, e	(27, 24), (46, 19)
2M J11095493–7635101	M5.75	4	e, A _V , NaK, ex	4
2M J11095505–7632409	<M0	3	ex, e	(27, 24), 3
2M J11095873–7737088	K0:; K7–M0, K7–M0, M1.25	6, 7, 8, 3	e, ex	(9, 10, 6, 7, 8, 12, 13, 3), (14, 45, 15, 16, 27, 24)
2M J11100010–7634578	<K6, K5:; <K6	7, 8, 19	e, ex, A _V	(9, 10, 18, 7, 8, 12, 13, 19), (15, 16, 23, 27, 24), 19
2M J11100192–7725451	M5.25	3	NaK, A _V	3
2M J11100336–7633111	M3–M5	4	e, ex, A _V	4
2M J11100369–7633291	K8	19	e, ex, A _V	(12, 19), (27, 24), 19
2M J11100469–7635452	M0, M1	8, 3	e, ex	(8, 3), (27, 24)
2M J11100658–7642486	M9.25	3	NaK	3
2M J11100704–7629376	K2:; K7, M0, M0	6, 7, 8, 3	e, ex, rv, A _V	(9, 10, 18, 6, 7, 8, 11, 12, 3), (45, 15, 16, 27, 24), (21, 17), 3
2M J11100785–7727480	M5, M5.5	39, 19	ex, NaK, A _V	(27, 24), 19, 19
2M J11100934–7632178	≥M9.5, M9.5	50, 3	H ₂ O, ex, NaK	50, 51, 3
2M J11101141–7635292	M1.5, M0, K5.5	34, 46, 19	ex, e, A _V	(27, 24), 19, 19
2M J11101153–7733521	M4.5	3	NaK, A _V	3
2M J11102226–7625138	M8	19	e, NaK	19

Table 2.: Known Members of Chamaeleon I: Spectral Types and Membership (continued)

Name	Spectral Type	References	Membership	References
2M J11102852–7716596	M5.5	19	NaK	19
2M J11103481–7722053	M4	19	NaK,Av	19
2M J11103644–7722131	M5,M4.75	39,19	NaK,Av	19
2M J11103801–7732399	K3,K3	11,48	ex,Li,rv	(14,45,43,15,27,24),(20,48),48
2M J11104006–7630547	M7.25	3	NaK,Av	3
2M J11104141–7720480	M2,M6	39,19	ex,e,NaK	(27,24),(39,19),19
2M J11104959–7717517	K7:,M2	8,19	e,ex,Av	(9,10,8,12,19),(15,27,24),19
2M J11105076–7718031	M4.5,M4.25	5,3	NaK,Av	(5,3)
2M J11105333–7634319	M1,M1:M3.75	7,8,3	e,ex	(9,10,18,6,7,8,11,12,27,3),(15,24)
2M J11105359–7725004	M5,M5,M4.5	39,34,19	ex,e,NaK,Av	(27,24),(39,19),19,19
2M J11105597–7645325	M5.75	19	ex,NaK	(15,27,24),19
2M J1111083–7641574	K7:,M2.5	5,3	e,Av,ex	(5,3),3,24
2M J11112249–7745427	M8.25	3	NaK,ex	3,44
2M J11112260–7705538	M4.5	19	NaK,Av	19
2M J11113474–7636211	K5-M0,M2.5	25,19	Li	25
2M J11113965–7620152	M0,M2,M1.5-M2.5	7,8,19	e,ex	(9,10,6,7,8,11,12,13,19),(15,16,24)
2M J11114533–7636505	M8	3	NaK,ex	3,44
2M J11114632–7620092	K1,K3,K3,K6	33,47,48,19	rv,e,Li,ex	(33,48),(33,47,48,19),(33,12,47,48),24
2M J11115400–7619311	M1,K7-M0,M2.5	12,25,3	Li	25
2M J11120288–7722483	M6	3	Av,NaK	3
2M J11120327–7637034	M5.5	19	NaK	19
2M J11120351–7726009	M3.5,M4.75,M6	39,19,5	ex,e,NaK,Av	(27,24),19,(19,5),(19,5)
2M J11120984–7634366	M5	19	e,NaK,ex	19,24
2M J11122250–7714512	M9.25	3	NaK,ex	3,24
2M J11122441–7637064	K3,K4	29,48	e,Li,ex,rv	29,48,(45,15,16,24),(21,48)
2M J11122772–7644223	G8,G9,G8:,K0	9,18,7,8	e,ex,rv	(9,10,18,7,8,12,30),(45,15,16,24),(21,17)
2M J11123092–7644241	M0.5,M1	16,19	e,Av,ex	(9,10,16,12,19),19,24
2M J11123099–7653342	M7	3	NaK	3
2M J11124210–7658400	K7,K5,M1	29,33,19	rv,Li,e,Av	33,33,19,19
2M J11124268–7722230	K0,G5-K0,G5	7,29,33	rv,Li,ex	33,33,(14,15,16,24)
2M J11124299–7637049	K5,K4	33,47	rv,Li	33,(33,47)
2M J11124861–7647066	M4	19	(Li,NaK),ex	19,24
2M J11132012–7701044	K0-M0,M2.75	25,19	Li	25,19

Table 2.: Known Members of Chamaeleon I: Spectral Types and Membership (continued)

Name	Spectral Type	References	Membership	References
2M J11132446–7629227	M3.5	19	NaK,ex	19,24
2M J11132737–7634165	M2.75	19	Li	25,19
2M J11132970–7629012	M4.25	19	Li,NaK	19
2M J11133356–7635374	M4.5	19	NaK	19
2M J11141565–7627364	M3.75	19	NaK	19
2M J11142454–7733062	M4	19	e,NaK,Av,ex	(12,19),19,19,24
2M J11142611–7733042	M5.75	19	(NaK,Av),ex	19,24
2M J11142906–7625399	M5.5,M4.75	5,3	NaK	5,3
2M J11145031–7733390	M2.75	19	Li	19
2M J11152180–7724042	M5.5,M4.75	5,3	NaK	5,3
2M J11155827–7729046	M4.5	3	NaK	3
2M J11160287–7624533	K,K7-M0	5,3	e	5,3
2M J11173700–7704381	M0.5,M0.5	8,19	e,ex	(9,10,6,7,8,12,19),(15,16,23)
2M J11173792–7646193	M5.75	3	NaK	3
2M J11175211–7629392	M4.5	3	NaK	3
2M J11181957–7622013	M2.25	19	Li	19
2M J11182024–7621576	K8	19	Li	25,19
2M J11183379–7643041	M5	3	NaK	3
2M J11194214–7623326	M5	3	NaK	3
2M J11195652–7504529	M7.25	3	NaK	3
2M J11241186–7630425	M5	3	(NaK,Av),ex	3,24
2M J11242980–7554237	M4.75	3	NaK	3
2M J11291261–7546263	K3	47,48	Li,μ	48,24
2M J11332327–7622092	M4.5	3	NaK	3

Table 3. References for Table 2

Number	Reference	Number	Reference
1	Houk & Cowley (1975)	27	Persi et al. (2000)
2	Perryman et al. (1997)	28	Vrba & Rydgren (1984)
3	Luhman (2007)	29	Feigelson & Kriss (1989)
4	Luhman & Muench (2008)	30	Gürtler et al. (1999)
5	Comerón et al. (2004)	31	Prusti et al. (1991)
6	Appenzeller (1979)	32	Lehtinen et al. (2001)
7	Rydgren (1980)	33	Walter (1992)
8	Appenzeller et al. (1983)	34	Gómez & Mardones (2003)
9	Henize & Mendoza (1973)	35	Luhman et al. (2006)
10	Schwartz (1977)	36	Comerón et al. (1999)
11	Whittet et al. (1987)	37	Reipurth et al. (1996)
12	Harju et al. (1993)	38	Comerón et al. (2000)
13	Natta et al. (2000)	39	Gómez & Persi (2002)
14	Baud et al. (1984)	40	Lawson et al. (1996)
15	Prusti et al. (1992b)	41	Neuhäuser & Comerón (1999)
16	Gauvin & Strom (1992)	42	Brandner & Zinnecker (1997)
17	Joergens & Guenther (2001)	43	Whittet et al. (1991b)
18	Appenzeller (1977)	44	Luhman et al. (2005b)
19	Luhman (2004a)	45	Assendorp et al. (1990)
20	Gregorio-Hetem et al. (1992)	46	Saffe et al. (2003)
21	Dubath et al. (1996)	47	Alcalá et al. (1995)
22	Whittet et al. (1997)	48	Covino et al. (1997a)
23	Henning et al. (1993)	49	Luhman et al. (2005c)
24	Luhman et al. (2008)	50	Luhman et al. (2004)
25	Huenemoerder et al. (1994)	51	Luhman et al. (2005a)
26	Luhman (2004b)		

of the census of known members and the molecular observations of the cloud imply a star formation efficiency of $\sim 10\%$ for Cha I, which is an upper limit since some of the cloud has probably dissipated, particularly in the northern half (Luhman 2007). The initial mass functions (IMFs) measured for two fields in Cha I are shown in Figure 12 (Luhman 2007). The IMF in Cha I reaches a maximum at a mass of $0.1\text{--}0.15 M_{\odot}$, which is similar to the turnover mass observed in IC 348 and the Orion Nebula Cluster (Hillenbrand 1997; Hillenbrand & Carpenter 2000; Muench et al. 2002, 2003; Luhman et al. 2003b). The substellar IMF is roughly flat in logarithmic units and shows no indication of reaching a minimum down to a completeness limit of $0.01 M_{\odot}$.

Spectral types and evidence of membership are less complete for Cha II than for Cha I. Spezzi et al. (2007, 2008) and Alcalá et al. (2008) claimed that their census of members of Cha II is complete to $0.03 M_{\odot}$ for $A_V < 2$. However, they only demonstrated that their photometry is complete to that mass limit, and did not show that their spectroscopic survey is complete to that limit. Indeed, 11 candidate members identified by Alcalá et al. (2008) and Spezzi et al. (2008) lack the spectroscopy needed to assess membership. Compilations of ~ 50 likely members of Cha II have been published by Alcalá et al. (2000), Young et al. (2005), and Spezzi et al. (2007, 2008). Spectroscopic confirmation of individual late-type members of Cha II has been presented by Barrado y Navascués et al. (2004), Alcalá et al. (2006), and Allers et al. (2007). In Figure 13, the positions of the known members of Cha II are plotted with the $100 \mu\text{m}$ IRAS map of the cloud. No young stars have been found in Cha III. Using data from the Hipparcos catalog, Sartori et al. (2003) identified 21 B- and A- type stars with distances between 100

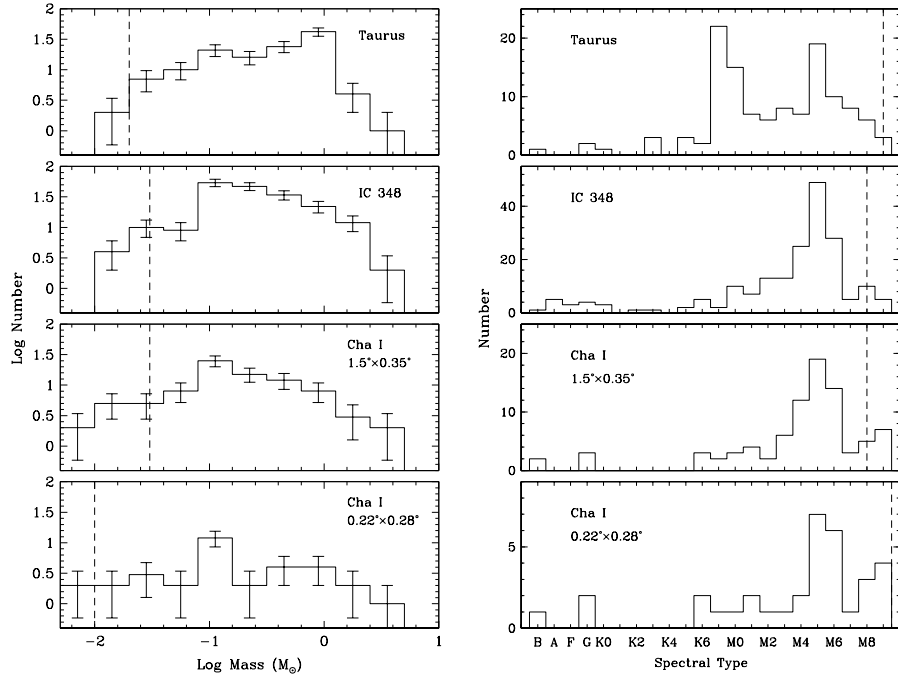


Figure 12. *Left:* IMFs from Luhman (2007) for extinction-limited samples in a field encompassing most of the Cha I cloud ($1.5^{\circ} \times 0.35^{\circ}$) and in a small area in the southern cluster of Cha I ($0.22^{\circ} \times 0.28^{\circ}$) compared to IMFs in Taurus (Luhman 2004d) and IC 348 (Luhman et al. 2003b). In the units of this diagram, the Salpeter slope is 1.35. *Right:* Distributions of spectral types in the IMFs. The completeness limits of these samples are indicated (*dashed lines*).

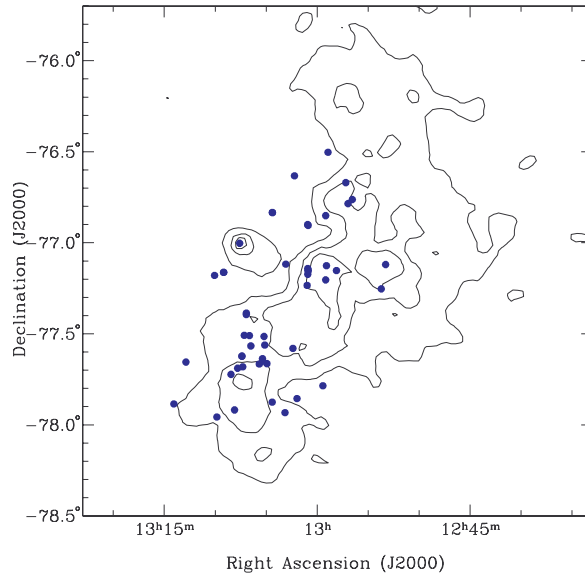


Figure 13. Spatial distribution of known members of Cha II (*points*, Alcalá et al. 2006; Allers et al. 2007; Spezzi et al. 2007, 2008). The contours represent the $100 \mu\text{m}$ map from IRAS.

and 200 pc and suggested that these stars comprise an OB association that is associated with the Chamaeleon clouds.

5. Multiplicity

Members of Chamaeleon have been targeted in several multiplicity surveys. Reipurth & Zinnecker (1993) and Brandner et al. (1996) used ground-based direct imaging at $\sim 1 \mu\text{m}$ to search for wide binaries among nearly 200 stars across the Chamaeleon cloud complex, including members of the widely distributed X-ray population (Alcalá et al. 1995). Brandner & Zinnecker (1997) obtained resolved spectroscopy and photometry for components of a sample of double stars found in those and other studies. The components of the pairs were roughly coeval when placed on the H-R diagram and compared to theoretical isochrones. Using photometry from 2MASS, Kraus & Hillenbrand (2007) performed a deeper search for wide companions in Cha I that reached substellar masses. They identified several candidate companions, some of which are discussed by Luhman (2007). To detect binaries at smaller separations among members of Chamaeleon, higher resolution imaging has been utilized, including K -band speckle (Ghez et al. 1997), adaptive optics (AO, Brandeker et al. 2001; Ahmic et al. 2007; Lafreniere et al. 2008), and the *Hubble Space Telescope* (Neuhäuser et al. 2002). The latter study focused on the Cha $H\alpha$ low-mass stars and brown dwarfs (Comerón et al. 1999, 2000; Neuhäuser & Comerón 1999). Because the primaries were intrinsically faint, the images from Neuhäuser et al. (2002) were capable of detecting companions at very low masses ($M_2 > 5 M_{\text{Jup}}$ at separations greater than $0''.35$). One promising candidate low-mass companion was identified, but it was later classified as a background star through spectroscopy (Neuhäuser et al. 2003). Like Neuhäuser et al. (2002), Ahmic et al. (2007) selected late-type members of Cha I for their AO survey, which consisted of 22 low-mass stars ($\leq M6$) and 6 brown dwarfs ($> M6$). Their data resolved the low-mass stars Cha $H\alpha$ 2, Hn 13, and CHXR 15 into doubles. Cha $H\alpha$ 2 was previously identified as a binary by Neuhäuser et al. (2002). Through proper motion measurements, Schmidt et al. (2008) demonstrated that neither of the components of Cha $H\alpha$ 2 is a background star. The most thorough multiplicity survey of Cha I to date was performed by Lafreniere et al. (2008), who obtained high-resolution images for 126 members with masses ranging from 0.1 to $3 M_{\odot}$ (the targets from Ahmic et al. (2007) represented a subsample of this survey).

During spectroscopy of candidate young brown dwarfs in Cha I, Luhman (2004b) serendipitously discovered a $1''.4$ pair of objects, 2MASS J11011926–7732383 A and B, that are likely to have substellar masses according to evolutionary models. The projected angular separation of this system corresponds to 240 AU at the distance of Cha I, making it the first known binary brown dwarf with a separation greater than 20 AU. In another survey for free-floating brown dwarfs in Cha I, Luhman et al. (2006) discovered a $1''.3$ companion to the low-mass star CHXR 73 using optical images obtained with the *Hubble Space Telescope*. Based on its spectral type and luminosity, this companion appears to have a mass of 10–15 M_{Jup} . Through K -band imaging of the area around Ced 110, Persi et al. (2001) resolved the protostar Ced 110 IRS6 as a $2''$ pair. During a near- and mid-IR multiplicity survey of protostars in nearby star-forming regions, Haisch et al. (2004, 2006) found that both components of Ced 110 IRS6 exhibit Class I spectral energy distributions. That survey also uncovered a $2''$ companion to ISO 97 that has a steeply rising spectral energy distribution, possibly indicative of a Class 0



Figure 14. The IRN as seen in a *JHK* color-composite image ($166'' \times 125''$, Zinnecker et al. 1999). North is up and east is left.

source. In their *Spitzer* survey of Cha I, Luhman et al. (2008) detected mid-IR excess emission from a faint source that is only $14''$ from IRN (directly left of IRN in Figure 14). Through near-IR spectroscopy, they classified it as a highly embedded young low-mass star ($A_J = 5.6$, M4). Luhman et al. (2008) also detected a very faint, red source $7''$ from the low-mass member 2MASS J11062942–7724586 (Figure 8) that is either a Class I brown dwarf or a galaxy. A compilation of known visual doubles with projected separations less than $5''$ in Cha I is provided in Table 4. Pairs with larger separations are resolved by 2MASS and thus can be found in Tables 1 and 2 if both components are confirmed members. Ghez et al. (1997) reported that CHXR 47 is a $1''.2$ binary based on seeing-limited images, but the AO images from Lafreniere et al. (2008) show that a pair of this kind is not present.

To detect tight binaries that are unresolved by direct imaging, high-resolution spectroscopy has been applied to members of Chamaeleon. For instance, surveys of a few dozen solar-mass young stars in and around the Chamaeleon clouds by Melo (2003) and Guenther et al. (2007) identified CHX18N, BF Cha, CS Cha, and RX J1220.6–7539 as spectroscopic binaries. Joergens & Guenther (2001) measured radial velocities for a dozen low-mass stars and brown dwarfs in Cha I at multiple epochs, finding possible variations due to low-mass unseen companions. Additional evidence of radial velocity variations has been provided by newer observations (Joergens 2006a), which comprise the first radial velocity monitoring survey of young low-mass stars and brown dwarfs. These observations have uncovered a $16\text{--}20\ M_{\text{Jup}}$ companion in a 1590 day orbit around the low-mass star Cha H α 8 (Joergens & Müller 2007).

6. Kinematics and Rotation

A modest amount of work has been done on the kinematics and rotation of members of Chamaeleon. Radial velocities have been measured through surveys for spectroscopic binaries (Reipurth et al. 2002; Melo 2003; Guenther et al. 2007) and through followup spectroscopy of X-ray sources in Cha I (Walter 1992), X-ray sources scattered across

Table 4. Visual Binaries in Chamaeleon I ($< 5''$)

Name	Separation (arcsec)	Reference
2M J11011926–7732383	1.44	1
2M J11103481–7722053	0.06	2
B53	0.30	2
Ced 110 IRS6	1.95	3,4
Cha H α 2	0.16	5,6,7
CHXR9C	0.96	8
CHXR15	0.30	6
CHXR26	1.40	9,2
CHXR28	1.87	8
CHXR30A	0.46	2
CHXR37	0.08	2
CHXR40	0.15	2
CHXR47	0.18	2
CHXR49NE	0.27	2
CHXR59	0.15	2
CHXR62	0.12	2
CHXR71	0.57	2
CHXR73	1.30	10
CHXR79	0.89	8,2
Hn4	0.21	2
Hn13	0.13	6
ISO97	2.05	11
ISO126	0.29	2
T3	2.22	12,2
T5	0.16	2
T14a	2.35	13,4
T21	0.14	2
T26	4.6,4.9	12,14
T27	0.79	12,2
T31	0.72,0.66	8,14
T33	2.43	12,14,4,2
T39	1.1	12
T41	0.79	14,2
T43	0.80	2
T45	0.75	14,2
T46	0.12	2
T51AB	1.98	12,14,2
T51BC	0.1	15
T54	0.25	14,2

(1) Luhman (2004b); (2) Lafreniere et al. (2008); (3) Persi et al. (2001); (4) Haisch et al. (2004); (5) Neuhäuser et al. (2002); (6) Ahmic et al. (2007); (7) Schmidt et al. (2008); (8) Brandner et al. (1996); (9) Luhman (2004a); (10) Luhman et al. (2006); (11) Haisch et al. (2006); (12) Reipurth & Zinnecker (1993); (13) Schwartz (1977); (14) Ghez et al. (1997); (15) Brandeker et al. (2001).

the cloud complex (Covino et al. 1997a), and candidate low-mass members of Cha I (Neuhäuser & Comerón 1999). Dedicated kinematic studies have been performed for both solar-mass stars (Dubath et al. 1996) and low-mass stars and brown dwarfs (Joergens & Guenther 2001; Joergens 2006b). As for stellar rotation, measurements of $v \sin i$ have been reported for a few dozen solar-mass stars (Franchini et al. 1988) and low-mass stars and brown dwarfs (Mohanty et al. 2005), mostly in Cha I. In some of the first measurements of periods for young low-mass objects through photometric monitoring, Joergens et al. (2003) observed rotational periods of a few days for low-mass stars and brown dwarfs, which agreed with the $v \sin i$ data for those objects (Joergens & Guenther 2001).

7. Herbig-Haro Objects and Outflows

During the objective prism survey of southern star-forming regions by Schwartz (1977), several Herbig-Haro (HH) nebulae were discovered in Cha I and II, consisting of HH 48-50 in the former and HH 52-54 in the latter. Schwartz et al. (1984) measured proper motions for these objects, which are relatively large given the proximity of the Chamaeleon clouds. They suggested that HH 49 and 50 are probably excited by B35, an embedded star 10' northeast of HH 50 and just east of Ced 110. During a survey at 1300 μm , Reipurth et al. (1996) discovered a candidate protostar, Cha-MMS1, that could be the driving source for HH 49-50. The star exciting these HH objects is probably also responsible for a compact CO outflow found by Prusti et al. (1991). However, through CO(3-2) observations, Belloche et al. (2006) and Hiramatsu et al. (2007) found that the outflow is produced by Ced 110 IRS4 rather than Cha-MMS1. Near- and mid-IR images of Ced 110 IRS4 are shown in Figures 8 and 15. The 24 μm image in Figure 8 detects Cha-MMS1 (Belloche et al. 2006; Luhman et al. 2008). A weaker outflow has been detected toward Ced 110 IRS6 (Hiramatsu et al. 2007).

A second protostar in Cha I detected at millimeter wavelengths by Reipurth et al. (1996) is probably the source of another molecular outflow from Mattila et al. (1989). This millimeter source, Cha-MMS2, likely corresponds to the young star T44 based on the agreement of their coordinates. Persi et al. (1999) suggested that a different protostar, ISO 192, is the exciting source for the CO outflow from Mattila et al. (1989). Persi et al. (2007) detected elongated nebulosity near ISO 192 in the direction of the outflow. However, Cha-MMS2/T44 is closer than ISO 192 to the center of the outflow.

Wang & Henning (2006) performed a deep survey in [S II] across a $1^\circ \times 2^\circ$ field encompassing the entire Cha I cloud, detecting a total of 18 HH objects. Bally et al. (2006) discovered additional fainter HH objects in Cha I through imaging of most of the cloud in $H\alpha$, [S II], i' , and broad-band mid-IR filters with *Spitzer*. Figure 16 shows an $H\alpha$ image from Bally et al. (2006) for HH objects in Cha I. These surveys have found no clear evidence for outflows from brown dwarfs in Cha I. Through images in [S II], Comerón & Reipurth (2006) discovered an HH jet from ESO $H\alpha$ 574. The faint photometric measurements of this object suggest that it has a substellar mass, but Luhman (2007) classified it as K7-M0, which is indicative of a solar-mass star. Thus, the faint apparent luminosity of this object is probably due to an edge-on disk (Comerón et al. 2004).

In Cha II, Graham & Hartigan (1988) obtained optical images and spectra for HH 52-54 and measured their velocities. Through millimeter CO imaging, Knee (1992) discovered a pair of outflows associated with HH 52-54. Possible exciting stars for



Figure 15. The area surrounding Ced 110 IRS4 as seen in a *JHK* color-composite image ($166'' \times 125''$, Zinnecker et al. 1999). North is up and east is left.

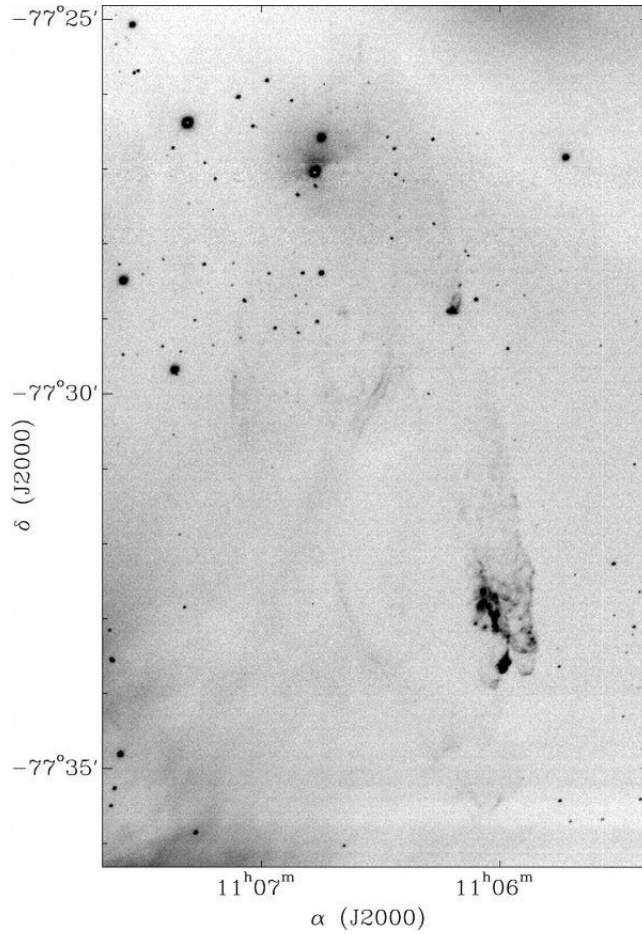


Figure 16. $H\alpha$ image of HH 49, 50, 906, and 925 in Cha I (Bally et al. 2006).

HH 52-54 have been discussed by Graham & Hartigan (1988), Hughes et al. (1991), and Knee (1992). HH 54 has been studied in detail with mid- and far-IR *ISO* and *Spitzer* spectroscopy of emission in CO, H₂O, H₂, [O I], [C II], [Ne II], [Fe II], [S I], and [Si II] (Liseau et al. 1996; Nisini et al. 1996; Neufeld et al. 1998; Giannini et al. 2006; Neufeld et al. 2006).

8. Circumstellar Disks

As with other aspects of star formation, Chamaeleon has been a valuable laboratory for studies of circumstellar disks. As discussed in Sections 4.4. and 4.5., IR photometry has been used to find new members by searching for objects that exhibit excess emission indicative of disks. Data of this kind also have been obtained for known members to determine if disks are present (Glass 1979). Kenyon & Gómez (2001) used *JHKL* photometry to estimate the fraction of members of Cha I with disks, and Jayawardhana et al. (2003) extended these measurements to lower masses with the Cha H α objects. Photometry at longer wavelengths has been measured for most of the known members of Cha I and II through wide-field imaging surveys with the *Spitzer Space Telescope* (Young et al. 2005; Allers et al. 2006; Porras et al. 2007; Alcalá et al. 2008; Damjanov et al. 2007; Luhman et al. 2005a,b,c, 2008; Luhman & Muench 2008). Pointed observations with *Spitzer* also have been performed toward young stars scattered across Chamaeleon that were found by Covino et al. (1997a) with *ROSAT* (Padgett et al. 2006). In these *Spitzer* data, mid-IR excess emission was detected for the faintest known members of Cha I, making them the least massive brown dwarfs observed to have circumstellar disks (Luhman et al. 2005a,c, 2008; Luhman & Muench 2008). Luhman et al. (2005b) measured disk fractions for 109 low-mass stars and brown dwarfs in Cha I and presented 3.6-8 μ m photometry for the objects later than M6. Using a subset of the images from Luhman et al. (2005b), Damjanov et al. (2007) performed a separate measurement of photometry for 81 known members and repeated the disk fraction measurement from Luhman et al. (2005b). Luhman et al. (2008) and Luhman & Muench (2008) analyzed all *Spitzer* images at 3.6-24 μ m that have been obtained near Cha I and presented compilations of the photometry for more than 200 known members appearing within those data. Luhman et al. (2008) found that their photometric errors were much smaller than those reported by Damjanov et al. (2007) for the same objects measured from the same images.

By combining the *Spitzer* photometry with the extensive census of known members that is available for Cha I, Luhman et al. (2008) investigated several aspects of the disk population in this cluster. They used the *Spitzer* colors to identify the members with disks, as illustrated in Figure 17, and measured the fraction of sources with disks as a function of mass from 0.01 to 3 $M_{\odot}$. As shown in Figure 17, the disk fraction for solar-type stars is higher in Cha I than in IC 348, even though the two clusters have the same age. Luhman et al. (2008) suggested that the lifetimes of disks around solar-mass stars in Cha I may be longer because of the lower stellar density. In addition, because many of the members of Cha I were observed at multiple epochs with *Spitzer*, Luhman et al. (2008) and Luhman & Muench (2008) were able to demonstrate that stars with disks have higher levels of mid-IR variability than diskless stars. Alcalá et al. (2008) performed a similar analysis of the disk population in Cha II by combining the *Spitzer* photometry from Young et al. (2005) and Porras et al. (2007) with data at other wavelengths.

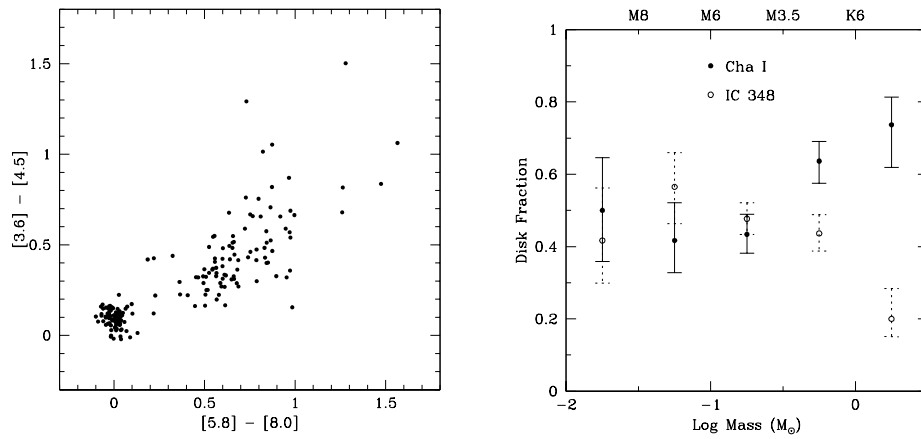


Figure 17. *Left:* Mid-IR color-color diagram for known members of Cha I (Luhman et al. 2008; Luhman & Muench 2008). Objects with inner disks and envelopes exhibit red colors that are distinctive from the neutral, photospheric colors of diskless members. *Right:* Disk fractions as a function of mass and spectral type for members of Cha I (Luhman et al. 2008) and IC 348 (Luhman et al. 2005b; Lada et al. 2006).

Disk-bearing members of Cha I and II identified in photometric surveys have been examined in detail through optical diagnostics of accretion and mid-IR spectroscopy and spectral energy distributions. For large samples of low-mass stars and brown dwarfs in Cha I, Natta et al. (2004), Muzerolle et al. (2005), and Mohanty et al. (2005) searched for evidence of accretion through high-resolution spectroscopy of emission in $H\alpha$, Ca II, and near-IR hydrogen transitions. Natta & Testi (2001), Apai et al. (2002), and Sterzik et al. (2004) constructed mid-IR spectral energy distributions for the low-mass objects Cha H α 1, 2, and 9 and compared the results to predictions of disk models. Bary et al. (2008) detected rovibrational H_2 emission from six members of Cha I (T11, T2, T32, T33A, T33B, T43), which they attribute to gas in circumstellar disks. Through mid-IR spectroscopy with *ISO* and *Spitzer*, grain growth and crystallinity have been studied in disks around solar-mass stars (Gürtler et al. 1999; Natta et al. 2000; Kessler-Silacci et al. 2006) and low-mass stars and brown dwarfs (Apai et al. 2005) in Cha I and Cha II. Mid-IR spectroscopy with *Spitzer* also has been used to characterize a disk with an inner hole, known as a transitional disk, around the solar-mass star CS Cha (Espaillat et al. 2007). The presence of an inner hole in this disk was originally suggested by observations of jet emission (Takami et al. 2003) and is probably at least partially caused by a stellar companion (Guenther et al. 2007). Additional candidate transitional disks in Cha I have been identified through *Spitzer* photometry (Damjanov et al. 2007; Luhman et al. 2008; Luhman & Muench 2008).

Because of the close proximity of Cha I, it has been possible to resolve a few disks in this cluster through direct imaging. For instance, the disk around the B star HD 97048 was imaged through mid-IR emission from polycyclic aromatic hydrocarbons (Lagage et al. 2006; Doucet et al. 2007) and optical scattered light images obtained with the *Hubble Space Telescope* (Doering et al. 2007). *Hubble* imaging also has resolved an edge-on disk around a low-mass star in Cha I (Luhman 2007).

Acknowledgments. This work was supported by grant AST-0544588 from the National Science Foundation. I thank Gerald Rhemann and Hans Zinnecker for providing the images for Figures 3, 14, and 15. This publication has made use of NASA's Astrophysics Data System Bibliographic Services, the SIMBAD database, operated at CDS in Strasbourg, France, and data products from 2MASS and DSS. 2MASS is a joint project of the University of Massachusetts and the Infrared Processing and Analysis Center/California Institute of Technology, funded by the National Aeronautics and Space Administration and the National Science Foundation. DSS was produced at the Space Telescope Science Institute under U.S. Government grant NAG W-2166.

References

- Ageorges, N., Fischer, O., Stecklum, B., Eckart, A., & Henning, T. 1996, *ApJ*, 463, L101
- Ahmic, M., Jayawardhana, R., Brandeker, A., Scholz, A., van Kerkwijk, M. H., et al. 2007, *ApJ*, 671, 2074
- Alcalá, J. M., Covino, E., Schmitt, J. H. M. M., Krautter, J., & Neuhäuser, R. 2000, *A&A*, 355, 629
- Alcalá, J. M., Krautter, J., Covino, E., Neuhäuser, R., Schmitt, J. H. M. M., & Wichmann, R. 1997, *A&A*, 319, 184
- Alcalá, J. M., Krautter, J., Schmitt, J. H. M. M., Covino, E., Wichmann, R., & Mundt, R. 1995, *A&AS*, 114, 109
- Alcalá, J. M., Spezzi, L., Chapman, N., Evans, N. J., Huard, T. L., et al. 2008, *ApJ*, 676, 427
- Alcalá, J. M., Spezzi, L., Frasca, A., Covino, E., Porras, A., et al. 2006, *A&A*, 453, L1
- Allers, K. N., Kessler-Silacci, J. E., Cieza, L. A., & Jaffe, D. T. 2006, *ApJ*, 644, 364
- Allers, K. N., Jaffe, D. T., Luhman, K. L., Liu, M. C., Wilson, J. C., et al. 2007, *ApJ*, 657, 511
- Apai, D., Pascucci, I., Henning, Th., Sterzik, M. F., Klein, R., et al. 2002, *ApJ*, 573, L115
- Apai, D., Pascucci, I., Bouwman, J., Natta, A., Henning, T., et al. 2005, *Sci*, 310, 834
- Appenzeller, I. 1977, *A&A*, 61, 21
- Appenzeller, I. 1979, *A&A*, 71, 305
- Appenzeller, I., Jankovics, I., & Krautter, J. 1983, *A&AS*, 53, 291
- Assendorp, R., Wesselius, P. R., Prusti, T., & Whittet, D. C. B. 1990, *MNRAS*, 247, 624
- Bally, J., Walawender, J., Luhman, K. L., & Fazio, G. 2006, *AJ*, 132, 1923
- Baraffe, I., Chabrier, G., Allard, F., & Hauschildt, P. H. 1998, *A&A*, 337, 403
- Barrado y Navascués, D., & Jayawardhana, R. 2004, *ApJ*, 615, 840
- Bary, J. S., Weintraub, D. A., Shukla, S. J., Leisenring, J. M., & Kastner, J. H. 2008, *ApJ*, 678, 1088
- Baud, B., Beintema, D. A., Wesselius, P. R., Young, E., Beichman, C. A., et al. 1984, *ApJ*, 278, L53
- Belloche, A., Parise, B., van der Tak, F. F. S., Schilke, P., Leurini, S., et al. 2006, *A&A*, 454, L51
- Bertout, C., Robichon, N., & Arenou, F. 1999, *A&A*, 352, 574
- Boulanger, F., Bronfman, L., Dame, T. M., & Thaddeus, P. 1998, *A&A*, 332, 273
- Brandeker, A., Liseau, R., Artymowicz, P., & Jayawardhana, R. 2001, *ApJ*, 561, L199
- Brandner, W., Alcalá, J. M., Kunkel, M., Moneti, A., & Zinnecker, H. 1996, *A&A*, 307, 121
- Brandner, W., & Zinnecker, H. 1997, *A&A*, 321, 220
- Briceño, C., Luhman, K. L., Hartmann, L., Stauffer, J. R., & Kirkpatrick, J. D. 2002, *ApJ*, 580, 317
- Cambrésy, L., Epchtein, N., Copet, E., de Batz, B., Kimeswenger, S., et al. 1997, *A&A*, 324, L5
- Cambrésy, L., Copet, E., Epchtein, N., de Batz, B., Borsenberger, J. et al. 1998, *A&A*, 338, 977
- Carpenter, J. M., Hillenbrand, L. A., Skrutskie, M. F., & Meyer, M. R. 2002, *AJ*, 124, 1001
- Cederblad, S. 1946, *Meddelanden fran Lunds Astronomiska Observatorium*, Ser. II, 119, 1
- Chabrier, G., Baraffe, I., Allard, F., & Hauschildt, P. H. 2000, *ApJ*, 542, 464

- Chiar, J. E., Ennico, K., Pendleton, Y. J., Boogert, A. C. A., Greene, T., et al. 2007, *ApJ*, 666, L73
- Cohen, M., & Schwartz, R. D. 1984, *AJ*, 89, 277
- Comerón, F., & Claes, P. 2004, *ApJ*, 602, 298
- Comerón, F., Neuhäuser, R., & Kaas, A. A. 2000, *A&A*, 359, 269
- Comerón, F., & Reipurth, B. 2006, *A&A*, 458, L21
- Comerón, F., Reipurth, B., Henry, A., & Fernández, M. 2004, *A&A*, 417, 583
- Comerón, F., Rieke, G. H., & Neuhäuser, R. 1999, *A&A*, 343, 477
- Covino, E., Alcalá, J. M., Allain, S., Bouvier, J., Terranegra, L., & Krautter, J. 1997a, *A&A*, 328, 187
- Covino, E., Palazzi, E., Penprase, B. E., Schwartz, H. E., & Terranegra, L. 1997b, *A&AS*, 122, 95
- Damjanov, I., Jayawardhana, R., Scholz, A., Ahmic, M., Nguyen, D. C., et al. 2007, *ApJ*, 670, 1337
- Dobashi, K., Uehara, H., Kandori, R., Sakurai, T., Kaiden, M., Umemoto, T., & Sato, F. 2005, *PASJ*, 57, 1
- Doering, R. L., Meixner, M., Holfeltz, S. T., Krist, J. E., Ardila, D. R., et al. 2007, *AJ*, 133, 2122
- Dubath, P., Reipurth, B., & Mayor, M. 1996, *A&A*, 308, 107
- Doucet, E., Habart, E., Pantin, C., Dullemond, P. O., Lagage, C., et al. 2007, *A&A*, 470, 625
- Espaillet, C., Calvet, N., D'Alessio, P., Bergin, E., Hartmann, L., et al. 2007, *ApJ*, 664, L111
- Feigelson, E. D., Casanova, S., Montmerle, T., & Guibert, J. 1993, *ApJ*, 416, 623
- Feigelson, E. D., & Kriss, G. A. 1989, *ApJ*, 338, 262
- Feigelson, E. D., & Lawson, W. A. 2004, *ApJ*, 614, 267
- Feigelson, E. D., Lawson, W. A., & Garmire, G. P. 2003, *ApJ*, 599, 1207
- Feldt, M., Henning, T., Lagage, P. O., Manske, V., Schreyer, K., & Stecklum, B. 1998, *A&A*, 332, 849
- Franchini, M., Stalio, R., & Magazzu, A. 1988, *A&A*, 189, 132
- Franco, G. A. P. 1991, *A&A*, 251, 581
- Gahm, G. F., Lehtinen, K., Carlqvist, P., Harju, J., Juvela, M., & Mattila, K. 2002, *A&A*, 389, 577
- Gauvin, L. S., & Strom, K. M. 1992, *ApJ*, 385, 217
- Ghez, A. M., McCarthy, D. W., Patience, J. L., & Beck, T. L. 1997, *ApJ*, 481, 378
- Giannini, T., McCoey, C., Nisini, B., Cabrit, S., Caratti o Garatti, A., et al. 2006, *A&A*, 459, 821
- Glass, I. S. 1979, *MNRAS*, 187, 305
- Gledhill, T. M., Chrysostomou, A., & Hough, J. H. 1996, *MNRAS*, 282, 1418
- Gómez, M., & Kenyon, S. J. 2001, *AJ*, 121, 974
- Gómez, M., & Mardones, D. 2003, *AJ*, 125, 2134
- Gómez, M., & Persi, P. 2002, *A&A*, 389, 494
- Graham, J. A., & Hartigan, P. 1988, *AJ*, 95, 1197
- Grasdalen, G., Joyce, R., Knacke, R. F., Strom, S. E., & Strom, K. M. 1975, *AJ*, 80, 117
- Gregorio-Hetem, J., Lépine, J. R. D., Quast, G. R., Torres, C. A. O., & de la Reza, R. 1992, *AJ*, 103, 549
- Gregorio-Hetem, J. C., Sanzovo, G. C., & Lépine, J. R. 1988, *A&AS*, 76, 347
- Gürtler, J., Schreyer, K., Henning, Th., Lemke, D., & Pfau, W. 1999, *A&A*, 346, 205
- Guenther, E., Esposito, M., Mundt, R., Covino, E., Alcalá, J. M., et al. 2007, *A&A*, 467, 1147
- Haikala, L. K., Harju, J., Mattila, K., & Toriseva, M. 2005, *A&A*, 431, 149
- Haisch, K. E., Barsony, M., Ressler, M. E., & Greene, T. P. 2006, *AJ*, 132, 2675
- Haisch, K. E., Greene, T. P., Barsony, M., & Stahler, S. W. 2004, *AJ*, 127, 1747
- Harjunpää, P., & Mattila, K. 1996, *A&A*, 305, 920
- Hartigan, P. 1993, *AJ*, 105, 1511
- Hayakawa, T., Cambrésy, L., Onishi, T., Mizuno, A., & Fukui, Y. 2001, *PASJ*, 53, 1109
- Hayakawa, T., Mizuno, A., Onishi, T., Hara, A., Yamaguchi, R., & Fukui, Y. 1999, *PASJ*, 51, 919

- Henize, K. G. 1963, *AJ*, 68, 280
- Henize, K. G., & Mendoza, E. E. 1973, *ApJ*, 180, 115
- Henning, T., Pfau, W., Zinnecker, H., & Prusti, T. 1993, *A&A*, 276, 129
- Hillenbrand, L. A. 1997, *AJ*, 113, 1733
- Hillenbrand, L. A., & Carpenter, J. M. 2000, *ApJ*, 540, 236
- Hiramatsu, M., Hayakawa, T., Tatematsu, K., Kamegai, K., Onishi, T., et al. 2007, *ApJ*, 664, 964
- Hoffmeister, C. 1962, *Z. Astrophysik*, 55, 290
- Houk, N., & Cowley, A. P. 1975, *University of Michigan Catalogue of Spectral Types*, Vol. 1., University of Michigan, Ann Arbor
- Huenemoerder, D. P., Lawson, W. A., & Feigelson, E. D. 1994, *MNRAS*, 271, 967
- Hughes, J., & Hartigan, P. 1994, *AJ*, 104, 680
- Hughes, J. D., Hartigan, P., Graham, J. A., Emerson, J. P., & Marang, F. 1991, *AJ*, 101, 1013
- Hyland, A. R., Jones, T. J., & Mitchell, R. M. 1982, *MNRAS*, 201, 1095
- Jayawardhana, R., Ardila, D. R., Stelzer, B., & Haisch, K. E. 2003, *AJ*, 126, 1515
- Joergens, V. 2006a, *A&A*, 446, 1165
- Joergens, V. 2006b, *A&A*, 448, 655
- Joergens, V., Fernández, M., Carpenter, J. M., & Neuhauser, R. 2003, *ApJ*, 594, 971
- Joergens, V., & Guenther, E. 2001, *A&A*, 379, L9
- Joergens, V., & Müller, A. 2007, *ApJ*, 666, L113
- Johnas, C. M. S., Guenther, E. W., Joergens, V., Schweitzer, A., & Hauschildt, P. H. 2007, *A&A*, 475, 667
- Jones, T. J., Hyland, A. R., Harvey, P. M., Wilking, B. A., & Joy, M. 1985, *AJ*, 90, 1191
- Kainulainen, J., Lehtinen, K., & Harju, J. 2006, *A&A*, 447, 597
- Kenyon, S. J., & Gómez, M. 2001, *AJ*, 121, 2673
- Kessler-Silacci, J., Augereau, J.-C., Dullemond, C. P., Geers, V., Lahuis, F., et al. 2006, *ApJ*, 639, 275
- Knee, L. B. G. 1992, *A&A*, 259, 283
- Kraus, A. L., & Hillenbrand, L. A. 2007, *ApJ*, 662, 413
- Lada, C. J., et al. 2006, *AJ*, 131, 1574
- Lafreniere, D., Jayawardhana, R., Brandeker, A., Ahmic, M., & van Kerkwijk, M. H. 2008, *ApJ*, in press
- Lagage, P.-O., Doucet, C., Pantin, E., Habart, E., Duchêne, G., et al. 2006, *Science*, 314, 621
- Larson, K. A., Whittet, D. C. B., Prusti, T., & Chiar, J. E. 1998, *A&A*, 337, 465
- Lawson, W. A., Feigelson, E. D., & Huenemoerder, D. P. 1996, *MNRAS*, 280, 1071
- Lehtinen, K., Haikala, L. K., Mattila, K., & Lemke, D. 2001, *A&A*, 367, 311
- Lehtinen, K., Harju, J., Kontinen, S., & Higdon, J. L. 2003, *A&A*, 401, 1017
- Liseau, R., Ceccarelli, C., Larsson, B., Nisini, B., White, G. J., et al. 1996, *A&A*, 315, L181
- Löhr, A., Bourke, T. L., Lane, A. P., Myers, P. C., Parshley, S. C., et al. 2007, *ApJS*, 171, 478
- López Martí, B., Eisloffel, J., & Mundt, R. 2005, *A&A*, 444, 175
- López Martí, B., Eisloffel, J., Scholz, A., & Mundt, R. 2004, *A&A*, 416, 555
- Luhman, K. L. 2004a, *ApJ*, 602, 816
- Luhman, K. L. 2004b, *ApJ*, 614, 398
- Luhman, K. L. 2004c, *ApJ*, 616, 1033
- Luhman, K. L. 2004d, *ApJ*, 617, 1216
- Luhman, K. L. 2007, *ApJS*, 173, 104
- Luhman, K. L., Adame, L., D'Alessio, P., Calvet, N., Hartmann, L., et al. 2005c, *ApJ*, 635, L93
- Luhman, K. L., Allen, L. E., Allen, P. R., Gutermuth, R. A., Hartmann, L., et al. 2008, *ApJ*, 675, 1375
- Luhman, K. L., Briceño, C., Stauffer, J. R., Hartmann, L., Barrado y Navascués, D., & Nelson, C. 2003a, *ApJ*, 590, 348
- Luhman, K. L., D'Alessio, P., Calvet, N., Allen, L. E., Hartmann, L., et al. 2005a, *ApJ*, 620, L51
- Luhman, K. L., Lada, C. J., Hartmann, L., Muench, A. A., Megeath, S. T., et al. 2005b, *ApJ*, 631, L69

- Luhman, K. L., & Muench, A. A. 2008, *ApJ*, 684, 654
- Luhman, K. L., Peterson, D. E., & Megeath, S. T. 2004, *ApJ*, 617, 565
- Luhman, K. L., Stauffer, J. R., Muench, A. A., Rieke, G. H., Lada, E. A., et al. 2003b, *ApJ*, 593, 1093
- Luhman, K. L., Wilson, J. C., Brandner, W., Skrutskie, M. F., Nelson, M. J., et al. 2006, *ApJ*, 649, 894
- Mattila, K., Liljeström, T., & Toriseva, M. 1989, in *ESO workshop on Low Mass Star Formation and Pre-Main Sequence Objects*, ed. Bo Reipurth, (ESO, Garching), 153
- McGregor, P. J., Harrison, T. E., Hough, J. H., & Bailey, J. A. 1994, *MNRAS*, 267, 755
- Melo, C. H. F. 2003, *A&A*, 269, 282
- Mendoza, E. E. 1972, *PASP*, 84, 641
- Mizuno, A., Hayakawa, T., Tachihara, K., Onishi, T., Yonekura, Y., et al. 1999, *PASJ*, 51, 859
- Mizuno, A., Hayakawa, T., Yamaguchi, N., Kato, S., Hara, A., et al. 1998, *ApJ*, 507, 83
- Mizuno, A., Yamaguchi, R., Tachihara, K., Toyoda, S., Aoyama, H., et al. 2001, *PASJ*, 53, 1071
- Mohanty, S., Jayawardhana, R., & Basri, G. 2005, *ApJ*, 626, 498
- Muench, A. A., Lada, E. A., Lada, C. J., & Alves, J. 2002, *ApJ*, 573, 366
- Muench, A. A., Lada, E. A., Lada, C. J., Elston, R. J., Alves, J. F., et al. 2003, *AJ*, 125, 2029
- Muzerolle, J., Luhman, K. L., Briceño, C., Hartmann, L., & Calvet, N. 2005, *ApJ*, 625, 906
- Naoi, T., Tamura, M., Nakajima, Y., Nagata, T., Suto, H., et al. 2006, *ApJ*, 640, 373
- Natta, A., Meyer, M. R., & Beckwith, S. V. W. 2000, *ApJ*, 534, 838
- Natta, A., & Testi, L. 2001, *A&A*, 376, L22
- Natta, A., Testi, L., Muzerolle, J., Randich, S., Comerón, F., & Persi, P. 2004, *A&A*, 424, 603
- Neufeld, D. A., Melnick, G. J., & Harwit, M. 1998, *ApJ*, 506, L75
- Neufeld, D. A., Melnick, G. J., Sonnentrucker, P., Bergin, E. A., Green, J. D., et al. 2006, *ApJ*, 649, 816
- Neuhäuser, R., & Comerón, F., 1998, *Sci*, 282, 83
- Neuhäuser, R., & Comerón, F., 1999, *A&A*, 350, 612
- Neuhäuser, R., Guenther, E., & Brandner, W. 2003, *IAU Symposium 211 Brown Dwarfs*, ed. E. Martín, Astronomical Society of the Pacific: San Francisco, 309
- Neuhäuser, R., Guenther, E., Mugrauer, M., Ott, T., & Eckart, A. 2002, *A&A*, 395, 877
- Nisini, B., Lorenzetti, D., Cohen, M., Ceccarelli, C., Giannini, T., et al. 1996, *A&A*, 315, L321
- Nordh, L., Olofsson, G., Abergel, A., Andre, P., Blommaert, J., et al. 1996, *A&A*, 315, L185
- Oasa, Y., Tamura, M., & Sugitani, K. 1999, *ApJ*, 526, 336
- Olmi, L., Felli, M., & Cesaroni, R. 1997, *A&A*, 326, 373
- Olmi, L., Felli, M., & Prusti, T. 1994, *A&A*, 288, 591
- Padgett, D. L., Cieza, L., Stapelfeldt, K. R., Evans, N. J., Koerner, D., et al. 2006, *ApJ*, 645, 1283
- Perryman, M. A. C., Lindegren, L., Kovalevsky, J., Hoeg, E., Bastian, U., et al. 1997, *A&A*, 323, L49
- Persi, P., Marenzi, A. R., Gómez, M., & Olofsson, G. 2001, *A&A*, 376, 907
- Persi, P., Marenzi, A. R., Gómez, M., & Olofsson, G. 2003, *A&A*, 399, 995
- Persi, P., Marenzi, A. R., Kaas, A. A., Olofsson, G., Nordh, L., & Roth, M. 1999, *AJ*, 117, 439
- Persi, P., Marenzi, A. R., Olofsson, G., Kaas, A. A., Nordh, L., et al. 2000, *A&A*, 357, 219
- Persi, P., Tapia, M., Gómez, M., Whitney, B. A., Marenzi, A. R., et al. 2007, *AJ*, 133, 1690
- Pontoppidan, K. M., Dartois, E., van Dishoeck, E. F., Thi, W.-F., & d'Hendecourt, L. 2003, *A&A*, 404, L17
- Porras, A., Jørgensen, J. K., Allen, L. E., Evans, N. J., Bourke, T. L., et al. 2007, *ApJ*, 656, 493
- Prusti, T., Clark, F. O., Whittet, D. C. B., Laureijs, R. J., & Zhang, C. Y. 1991, *MNRAS*, 251, 303
- Prusti, T., Whittet, D. C. B., Assendorp, R., & Wesselius, P. R. 1992a, *A&A*, 260, 151
- Prusti, T., Whittet, D. C. B., & Wesselius, P. R. 1992b, *MNRAS*, 254, 361
- Reipurth, B., Lindgren, H., Mayor, M., Mermilliod, J.-C., & Cramer, N. 2002, *AJ*, 124, 2813
- Reipurth, B., Nyman, L.-Å., & Chini, R. 1996, *A&A*, 314, 258
- Reipurth, B., & Zinnecker, H. 1993, *A&A*, 278, 81
- Robrade, J., & Schmitt, J. H. M. M. 2007, *A&A*, 461, 669

- Rydgren, A. E. 1980, *AJ*, 85, 444
- Saffé, C., Randich, S., Mardones, D., Caselli, P., Persi, P., & Racca, G. 2003, *A&A*, 409, 993
- Sartori, M. J., Lépine, J. R. D., & Dias, W. S. 2003, *A&A*, 404, 913
- Schmidt, T. O. B., Neuhäuser, R., Vogt, N., Seifahrt, A., Roell, T., & Bedalov, A. 2008, *A&A*, 484, 413
- Schwartz, R. D. 1977, *ApJS*, 35, 161
- Schwartz, R. D. 1991, in *Low Mass Star Formation in Southern Molecular Clouds*, ESO Scientific Report No. 11, ed. B. Reipurth, 93
- Schwartz, R. D., & Henize, K. G. 1983, *AJ*, 88, 1665
- Schwartz, R. D., Jones, B. F., & Sirk, M. 1984, *AJ*, 89, 1735
- Siebenmorgen, R., Natta, A., Kruegel, E., & Prusti, T. 1998, *A&A*, 339, 134
- Siebenmorgen, R., Prusti, T., Natta, A., & Mueller, T. G. 2000, *A&A*, 361, 258
- Skrutskie, M., Cutri, R. M., Stiening, R., Weinberg, M. D., Schneider, S., et al. 2006, *AJ*, 131, 1163
- Spezzi, L., Alcalá, J. M., Covino, E., Frasca, A., Gandolfi, D., et al. 2008, *ApJ*, 680, 1295
- Spezzi, L., Alcalá, J. M., Frasca, A., Covino, E., & Gandolfi, D. 2007, *A&A*, 470, 281
- Steenman, H., & Thi, P. S. 1989, *Ap&SS*, 161, 99
- Stelzer, B., & Micela, G. 2007, *A&A*, 474, 129
- Stelzer, B., Micela, G., & Neuhäuser, R. 2004, *A&A*, 423, 1029
- Sterzik, M. F., Pascucci, I., Apai, D., van der Blik, N., & Dullemond, C. P. 2004, *A&A*, 427, 245
- Takami, M., Bailey, J., & Chrysostomou, A. 2003, *A&A*, 397, 675
- Tamura, M., Itoh, Y., Oasa, Y., & Nakajima, T. 1998, *Sci*, 282, 1095
- Tennekes, P. P., Harju, J., Juvela, M., & Tóth, L. V. 2006, *A&A*, 456, 1037
- Toriseva, M., & Mattila, K. 1985, *A&A*, 153, 207
- Toriseva, M., Mattila, K., & Bronfman, L. 1990, *A&AS*, 171, 219
- Vrba, F. J., & Rydgren, A. E. 1984, *ApJ*, 283, 123
- Vuong, M. H., Cambrésy, L., & Epchtein, N. 2001, *A&A*, 379, 208
- Walter, F. M. 1992, *AJ*, 104, 758
- Wang, H., & Henning, T. 2006, *ApJ*, 643, 985
- Whittet, D. C. B., Assendorp, R., Prusti, T., Wesselius, P. R., & Roth, M. 1991a, *A&A*, 251, 524
- Whittet, D. C. B., Gerakines, P. A., Carkner, A. L., Hough, J. H., Martin, P. G., Prusti, T., & Kilkenny, D. 1994, *MNRAS*, 268, 1
- Whittet, D. C. B., Prusti, T., & Wesselius, P. R. 1991b, *MNRAS*, 249, 319
- Whittet, D. C. B., Kirrane, T. M., Kilkenny, D., Oates, A. P., Watson, F. G., et al. 1987, *MNRAS*, 224, 497
- Whittet, D. C. B., Prusti, T., Franco, G. A. P., Gerakines, P. A., Kilkenny, D., et al. 1997, *A&A*, 327, 1194
- Wichmann, R., Bastian, U., Krautter, J., Jankovics, I., & Ruciński, S. M. 1998, *MNRAS*, 301, L39
- Yamauchi, S., Hamaguchi, K., Koyama, K., & Murakami, H. 1998, *PASJ*, 50, 465
- Young, K. E., Harvey, P. M., Brooke, T. Y., Chapman, N., Kauffmann, J., et al. 2005, *ApJ*, 628, 283
- Zinnecker, H., Krabbe, A., McCaughrean, M. J., Stanke, T., Stecklum, B., et al. *A&A*, 352, L73