# Protoplanetary and Transitional Disks in the Open Stellar Cluster IC 2395

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### ABSTRACT

We present new deep UBVRI images and high-resolution multi-object optical spectroscopy of the young (~ 6 - 10 Myr old), relatively nearby (800 pc) open cluster IC 2395. We identify nearly 300 cluster members and use the photometry to estimate their spectral types, which extend from early B to middle M. We also present an infrared imaging survey of the central region using the IRAC and MIPS instruments on board the *Spitzer Space Telescope*, covering the wavelength range from 3.6 to  $24 \,\mu$ m. Our infrared observations allow us to detect dust in circumstellar disks originating over a typical range of radii ~ 0.1 to ~ 10 AU from the central star. We identify 18 Class II, 8 transitional disk, and 23 debris disk candidates, respectively 6.5%, 2.9%, and 8.3% of the cluster members with appropriate data. We apply the same criteria for transitional disk identification to 19 other stellar clusters and associations spanning ages from ~ 1 to ~ 18 Myr. We find that the number of disks in the transitional phase as a fraction of the total with strong 24  $\mu$ m excesses ([8] - [24]  $\geq$  1.5) increases from 8.4  $\pm$  1.3% at

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 $\sim 3$  Myr to  $46 \pm 5\%$  at  $\sim 10$  Myr. Alternative definitions of transitional disks will yield different percentages but should show the same trend.

Subject headings: stars: pre-main-sequence – circumstellar matter – infrared: stars; IC 2395

### 1. Introduction

The Spitzer Space Telescope (Spitzer; Werner et al. 2004) has significantly improved our understanding of how protoplanetary disks form, evolve, and eventually dissipate. By 15 Myr the accretion of gas onto protostars has largely ceased and most primordial disks have dissipated (eg. Haisch et al. 2001; Mamajek et al. 2004; Meng et al. 2016). By this time, planetesimals have formed and dust produced in their collisions yields planetary debris disks. These regenerated disks indirectly reveal the presence of planetary bodies required to replenish the dust and allow us to trace the evolution of planetary systems over the full range of stellar ages (e.g., Lagrange et al. 2000; Dominik & Decin 2003; Wyatt 2008; Gáspár et al. 2013; Sierchio et al. 2014).

The beginning of the transition from an optically-thick accretion disk to an opticallythin debris disk occurs from the inside-out (e.g. Skrutskie et al. 1990; Sicilia-Aguilar et al. 2005; Megeath et al. 2005; Muzerolle et al. 2010; Espaillat et al. 2014) and is marked by a characteristic spectral energy distribution (SED) with little excess at shorter ( $< 6\mu$ m) wavelengths but still retaining strong emission at the longer ones. These "transitional" disks appear to represent the process of clearing "caught in the act". The result is a largely evacuated inner region accompanied by an optically-thick primordial disk at larger radii. This phase is crucial to our understanding of disk dissipation and planet formation because it signals the end of stellar accretion and the consumption of nearly all the gas in the disk. Given the small number of transitional disks identified relative to the number of primordial and debris disks, it has been concluded that this phase is of short duration, on the order of a few hundred thousand years (Skrutskie et al. 1990; Kenyon & Hartmann 1995; Simon & Prato 1995; Wolk & Walter 1996; Muzerolle et al. 2010; Espaillat et al. 2014).

The key time period to observe the transitional phase is from a few to about 15 Myr. Clusters and associations are ideal laboratories for studying disk evolution as the member stars are coeval to within a few million years, of similar composition and reddening, at similar and reliably measured distance, and numerous enough to have a wide range of masses and to support drawing statistically valid conclusions. Unfortunately, there are only a few appropriately aged young clusters within a kiloparsec to support characterizing the transitional disk phase. For more distant clusters, *Spitzer* has insufficient sensitivity in the mid-infrared to measure the photospheres of the lowest mass members and to identify complete samples of transitional disks.

The open cluster IC 2395 can augment studies of this phase of disk evolution. The cluster is 800 pc distant (Section 3.3, Claria et al. 2003). Despite its proximity, it has not been extensively studied. Claria et al. (2003) conducted the largest photometric investigation of the cluster, identifying candidate members and estimating the cluster's age, distance, extinction, and angular size. Sensitive to a limiting magnitude of V < 15 mag, their survey found 78 probable and possible members through UBV photometry. There have also been several proper motion studies but none combined with photometric data. The cluster age has been estimated at  $6 \pm 2$  Myr (Claria et al. 2003) on the traditional calibration for young cluster and association ages (e.g., Mamajek 2009). A revised age calibration has been proposed (e.g., Pecaut et al. 2012; Bell et al. 2013, 2015), on which we derive in this paper an age of ~ 9 Myr (Section 3.3). On either calibration, IC 2395 is in the critical range to characterize transitional disk behavior.

To increase our understanding of this cluster, we have obtained ~ 45 square arcmin fields of deep optical (*UBVRI*), and mid-IR (3.6, 4.5, 5.8, 8.0 and  $24 \,\mu$ m) photometry and high-resolution optical spectroscopy of IC 2395. We describe the new observations in Section 2 and discuss the cluster membership and age in Section 3. In Section 4, we identify and characterize the circumstellar disks in the cluster with emphasis on identifying transitional disks. We combine these results with a homogeneous treatment of transitional disks in 19 other young clusters and associations in Section 5, to probe the evolution of circumstellar disks through the transitional phase. We summarize and conclude the paper in Section 6.

#### 2. Observations and Sample Selection

In this section, we discuss the *Spitzer* observations and data reduction for IC 2395, as well as our optical UBVRI observations and spectroscopy of selected probable members. In addition to the photometry described below, we took JHK measurements from 2MASS. We also re-examine the results of Claria et al. (2003) and include appropriate members from their work in our study.

# 2.1. Spitzer/IRAC

IC 2395 was observed using IRAC (Fazio et al. 2004) on *Spitzer* on 2003 December as part of a GTO program (PID 58, PI Rieke, Evolution and Lifetimes of Protoplanetary Disks) to study protoplanetary disks and dust evolution. The survey covers a  $\approx 44' \times 44'$  area (9 by 9 grid, ~0.54 square degrees) in each of the four IRAC channels. The 12 s high-dynamicrange mode was used to obtain two frames in each position, one with 0.4 s exposure time and one with 10.4 s. The observation of each field was repeated twice with a small offset, providing 20.8 s integration time for each position. The frames were processed using the Spitzer Science Center (SSC) IRAC Pipeline v14.0, and mosaics were created from the basic calibrated data (BCD) frames using using a custom IDL package, Cluster Grinder, that treats bright source artifacts and removes cosmic ray hits and spatial scale distortion during mosaic construction (Gutermuth et al. 2009). Due to the 7 arcmin offset between channels 1/3 and channels 2/4, the total area covered in all four channels is about 0.37 square degrees.

The IDL-based photometry visualization tool PhotVis version 1.10 (Gutermuth et al. 2008) was used on the reduced images to find sources and carry out aperture photometry on them. The radii of the source aperture, and of the inner and outer boundaries of the sky annulus, were 2.4, 2.4, and 7.2 arcsec, respectively. The calibration was based on large-aperture measurements of standard stars. The zero point magnitudes of the calibration were 19.6642, 18.9276, 16.8468, and 17.3909 corresponding to zero point fluxes of 280.9, 179.7, 115.0, and 64.13 Jy for channels 1, 2, 3, and 4, respectively (Reach et al. 2005). Corrections of 0.21, 0.23, 0.35, and 0.5 mag were applied for channels 1, 2, 3, and 4, respectively, to correct for the differences between the aperture sizes used for the IC 2395 sources and for the standard stars.

### 2.2. Spitzer/MIPS

IC 2395 was also observed using MIPS on *Spitzer* in 2003 as part of the same GTO program. MIPS is equipped with a three-channel camera with central wavelengths of approximately 24, 70, and 160  $\mu$ m (Rieke et al. 2004). The longer wavelength channels are insensitive to stellar photospheric emission at the distance of IC 2395 and no cluster stars were detected at 70  $\mu$ m nor 160  $\mu$ m. This study is based on only the MIPS 24  $\mu$ m channel.

The observations used the medium scan mode with half-array cross-scan offsets resulting in a total exposure time per pixel of 80 s. The images were processed using the MIPS instrument team Data Analysis Tool (Gordon et al. 2005), which calibrates the data, corrects distortions, and rejects cosmic rays during the coadding and mosaicking of individual frames. A column-dependent median subtraction routine was applied to remove any residual patterns from the individual images before combining them into the final  $24 \,\mu \text{m}$  mosaic. The total area mapped was nearly a square degree ( $89' \times 40'$ ).

We measured the 24  $\mu$ m flux density of individual sources using the standard photometry routine allstar in the IRAF data reduction package daophot, and within a 15" aperture. We then applied an aperture correction of 1.73 to account for the flux density outside the aperture, as determined from the STinyTim 24  $\mu$ m PSF model (Engelbracht et al. 2007). Finally, fluxes were converted into magnitudes referenced to the Vega spectrum (with the zero point at 7.17 Jy). Typical 1- $\sigma$  measurement uncertainties for the MIPS 24  $\mu$ m fluxes are 50  $\mu$ Jy; there is also a ~2% uncertainty in the absolute calibration (Engelbracht et al. 2007). The MIPS image is sufficiently sensitive to detect the photospheres of ~ A0 stars at the distance of IC 2395.

Figure 1 is a three-color composite image composed of IRAC wavelengths 3.6  $\mu$ m (blue) and 8  $\mu$ m (green) and MIPS 24  $\mu$ m (red). The shortest wavelength channel reaches the photospheres of all stars in the cluster. In addition, however, it also picks up many background stars. The 8  $\mu$ m image shows fewer sources and highlights dust (and associated gas). This image likely has a polycylic aromatic hydrocarbon contribution and potentially also silicate emission at its long wavelength limit. At 24  $\mu$ m, we see cooler extended dust and the cluster members with significant excess emission. The brightest source is EP Velorum, an M6 asymptotic giant branch, thermally pulsating star (Kerschbaum & Hron 1994), unassociated with the cluster. The 24  $\mu$ m mosaic of the central region of IC 2395 is displayed in Figure 2, with the most prominent infrared-excess sources marked.

### 2.3. UBVRI Photometry

Our optical observations were made with the SITe 2048-#6 CCD camera on the 1.5-m telescope at CTIO on 2003 Jan 23 and 24 as part of a 3 day campaign (2003 Jan 22, 23, and 24) to provide optical data in support of *Spitzer* observations for IC 2395 and NGC 2451 (discussed in a separate paper; Balog et al. (2009)). The camera was mounted at the f/13.5 focal position, covering a  $15 \times 15$  arcmin<sup>2</sup> field-of-view with a resolution of 0.43 arcsec/pixel for the entire  $2048 \times 2048$  pixel<sup>2</sup> area. The observations were made through Johnson-Cousins UBVRI filters, applying the Tek #1 filter set<sup>1</sup>.

The whole cluster was covered by  $3 \times 3 = 9$  CCD frames centered on and around the

<sup>&</sup>lt;sup>1</sup>http://www.ctio.noao.edu/instruments/filters

brightest inner area at R.A. = 08:42:30, DEC = -48:06:00. One off-cluster area (separated by ~ 1.5 deg from the cluster center) was also imaged to sample the foreground/background object population in the same line-of-sight. Each field was imaged three times through the same filter. One frame was obtained with a short exposure time (10 s for U and 5 s for BVRI) and the other two frames were taken with longer ones (250 s for U, 70 s for B and 50 s for VRI).

The reduction of the raw frames was performed with standard routines using  $IRAF^2$ . After trimming the edges of the frames and subtracting the bias level from each image, the frames were divided by a master flat field image obtained by median combining the available flat field frames for each filter. Both dome flats and sky flats were taken at the beginning of each night and combined together into the master flat frames. After flat field division, the two long-exposure frames corresponding to the same filter were averaged to increase the signal-to-noise.

The photometry of the cluster frames was conducted via PSF-fitting using DAOPHOT implemented in *IRAF*. A 2nd order spatially variable PSF (varorder=2) was built for each frame to help compensate for the distortions of the PSFs due to either the optical imaging artifacts in the large field-of-view, or guiding errors that occured randomly on a few frames. The model function=penny2 was selected to account for the slight elongation of the PSF. The PSF-stars were selected interactively from a sample of the ~ 100 brightest, non-saturated, well isolated stars on each frame, omitting the ones with suspicious profiles and/or detectable neighbors within r = 15 pixels. The fitrad parameter was set according to the value of the FWHM. The detection threshold was fixed at the 4- $\sigma$  level on each frame.

The transformation of the CTIO instrumental magnitudes into the standard Johnson-Cousins system was performed via the observations of Landolt photometric standard sequences (Landolt 1992). The description of the standard transformation is discussed in Balog et al. (2009).

We applied aperture corrections for each frame to match the PSF photometry to the aperture photometry obtained for standard stars. The aperture photometry was computed with  $r_{ap} = 8$  pixels radius. The local sky level was estimated as the mode of the pixel distribution within an annulus having inner and outer radii of 10 and 20 pixels, respectively, centered on each object. Inspecting the final instrumental magnitudes we found a very small 0.02-0.03 mag systematic offset between the long and short exposure frames and also found that there is a ~0.03-0.1 mag offset between the different frames of the mosaics. We tied

 $<sup>{}^{2}</sup>IRAF$  is distributed by NOAO which is operated by the Association of Universities for Research in Astronomy (AURA) Inc. under cooperative agreement with the National Science Foundation

our photometry to the middle frame (which overlaps with all of the remaining fields) of the  $3 \times 3$  mosaic to ensure the consistency of our dataset.

We tested the quality and stability of the photometry, including the standard transformation, by comparing our standard magnitudes with those from Claria et al. (2003) (unfortunately, only the V and B - V data could be compared this way). We discovered  $\simeq 0.19$ mag and  $\simeq 0.015$  mag systematic offsets between the two datasets in V and B-V respectively. Claria et al. (2003) report that there were systematic differences (sometimes as large as 0.2 mag) between their photometry and earlier work. We therefore also compared our photometry with stars from the field found in the SIMBAD database. The systematic offsets were smaller; however, the scatter of the data was much larger due to the non-uniformity of the SIMBAD data. However, we used the exact same calibration in the case of NGC 2451 (Balog et al. 2009) where we found an almost perfect agreement with the previously published dataset of Platais et al (2001). In cases where an object is missing from our photometric sample we adjust its Claria et al. (2003) photometry to match ours and give that value in the summary table for all the members.

## 2.4. Spectroscopy

We acquired AAOmega spectra using the Anglo-Australian Telescope at Siding Spring, Australia on three nights (17-23 December 2009) in conditions of clear skies with 1.5-2.5 arcsec seeing.

## 2.4.1. Target Selection

To make optimal use of the telescope time, we pre-selected member candidates based on their positions on the color magnitude (CM) diagram and color-color (CC) diagram. The 2MASS near-infrared photometry in particular is useful in deselecting reddened background stars. We matched our optical photometry to the 2MASS positions and used the V vs. V-K CM diagram and the V-K vs. V-I CC diagram to separate possible cluster members from the foreground and background population. We selected stars as member candidates if their positions on the CM diagram were compatible with the cluster age, distance and reddening allowing for errors due to binarity and age spread. First we combined the premain-sequence isochrones with ages 3 and 10 Myr (traditional age calibration) of Palla & Stahler (1999) with the post-main-sequence isochrones of Marigo et al. (2008). We selected these isochrones because they bracket the age of the cluster ( $\sim$  6 Myr on this calibration) and allow some room for errors in the age estimates. Then we shifted these isochrones to the distance modulus of IC2395 (800 pc) and applied additional shifts to take into account the reddening and extinction. We show the CC diagram with the selected possible members in Figure 3. We also included all objects that showed some level of IR excess in the IRAC bands even when they were not covered by our optical imaging<sup>3</sup> Altogether 710 candidates were selected based on the above criteria. We were able to obtain spectra of 675 of the candidates.

### 2.4.2. Observations and Data Processing

In the blue arm of the spectrograph, we used the 2500 V grating, providing  $\lambda/\Delta\lambda = 8000$  spectra between 4800 Å and 5150 Å. In the red arm we used the 1700 D grating that has been optimized for recording the Ca II IR triplet region. The red spectra range from 8350 Å to 8790 Å, with  $\lambda/\Delta\lambda = 10000$ . This setup has the highest spectral resolution available with AAOmega, suitable to measure stellar radial velocities. In total, we acquired 11 field configurations centered on the open cluster. The spectra were reduced using the standard Two-Degree Field data reduction pipeline. We performed continuum normalization for the stellar spectra using the IRAF task onedspec.continuum and then cleaned the strongest skyline residuals using linear interpolation of the surrounding continuum (see Balog et al. 2009 for a detailed description of the data processing of AAOmega).

Balog et al. (2009) also describe the methodology for radial velocity determination. In summary, an iterative process was used to fit the atmospheric absorptions and the stellar radial velocity, based on synthetic stellar spectra. Our method is similar to that of the Radial Velocity Experiment (RAVE) project (Steinmetz et al. 2006; Zwitter et al. 2008), including use of the same library of synthetic spectra. We required three iterations to converge to a stable set of temperatures, surface gravities, metallicities, and radial velocities. We estimate the velocities to be accurate within  $\pm 1 - 2 \text{ km s}^{-1}$  for the cooler stars (T < 8000 - 9000 K) and  $\pm 5 \text{ km s}^{-1}$  for the hotter ones.

<sup>&</sup>lt;sup>3</sup>The objects without V and I photometry (numbers 1, 2, 3, 4, 111, 134, 167, and 278) include one identified as a transitional disk (134), two as class II sources (111, 167), and one as a debris disk (278): the ratio of the number of transitional to class II sources is identical to the overall value, so the selection of these objects does not bias our results on the incidence of transitional systems.

### 3. Cluster Membership

#### 3.1. High mass members from Claria et al. (2003)

We now describe our identification of cluster members. Associating stars to stellar clusters can be challenging and is best carried out using several criteria, all of which need to be consistent with membership. The most confident membership designations are those that have photometric, kinematic, and spectroscopic measurements. In the case of IC 2395, no previous study has constructed a membership list based on multiple criteria.

Claria et al. (2003) conducted a UBV investigation of the cluster's central  $50' \times 50'$ region to a V band limiting magnitude of 15. This survey is the starting point for our identification of the high-mass cluster members. They selected cluster members photometrically by examining the positions of the observed stars in UBV color-magnitude and color-color diagrams with respect to the theoretical models of Lejeune & Schaerer (2001). Stars lying no more than 0.75 mag above the zero-age main sequence (ZAMS) and deviating no more than 0.10 mag from the CC main sequence locus were classified as cluster members. Claria et al. (2003) presented 61 sources meeting these photometric criteria. The CM and CC diagram positions of another 16 stars were somewhat ambiguous but they were retained as possible members.

A comparison of 21 of these cluster members to a proper-motion-selected list from Dias et al. (2001) showed very good agreement; however, the uncertainties in the mean proper motion survey are sufficiently large to make the comparison inconclusive. Without a kinematic, spectroscopic, or near-infrared membership criterion to go along with the visible photometry, we believe that the Claria et al. (2003) classification is insufficient for providing a robust list of bona fide cluster members.

## 3.1.1. Mean Cluster Proper Motion

We add a kinematic criterion to the Claria et al. (2003) photometric membership list by selecting on proper motion. There are multiple estimates of the mean proper motion of IC 2395 members, but some of the estimates are inconsistent. We re-estimated the mean proper motion using the spectroscopically confirmed sample of 14 B-type cluster members selected from Claria et al. (2003). The NOMAD catalog from USNO (Zacharias et al. 2004) provides the best available proper motion for each star (usually from Tycho-2 or Hipparcos; Hogg et al. 2000; Brown et al. 1997). Twelve of the 14 had proper motions with the exceptions being HD 74455 and HD 74436. The variance-weighted mean  $\mu_{\alpha} cos\delta$  and  $\mu_{\delta}$  values were calculated and the  $\chi^2$  of each value was calculated for the sample. One star, HD 74251, was rejected due to contributing (by far) the majority of the  $\chi^2$  for both  $\mu_{\alpha}\cos\delta$  and  $\mu_{\delta}$ . Further clipping, however, had negligible effect on the final proper motion, so we calculated the mean proper motion value for the remaining 11 B-stars as representative for the group:  $\langle \mu_{\alpha}\cos\delta \rangle = -3.9 \pm 0.4 \text{ mas yr}^{-1}$  and  $\langle \mu_{\delta} \rangle = +3.0 \pm 0.4 \text{ mas yr}^{-1}$ . As the variance-weighted mean uncertainty ( $\sim 0.3 \text{ mas yr}^{-1}$ ) was close to the uncertainty in the Tycho-2 reference system proper motion ( $\sim 0.25 \text{ mas yr}^{-1}$ ), we conservatively added that term in quadrature to derive our final uncertainty estimate ( $\sim 0.4 \text{ mas yr}^{-1}$ ). The mean proper motion is consistent within the errors whether we calculate it as a true median (Gott 2001), a Chauvenet-criterion clipped mean (Bevington & Robinson 1992), or an unweighted mean, so our choice of  $\mu$  estimation matters little.

Our derived mean proper motion agrees well with most of the previously measured values as shown in Table 1 (Kharchenko et al. 2005, 2003; Loktin et al. 2003; Dias et al. 2002, 2001; Baumgardt et al. 2000), but is severely at odds with the quoted values from Gulyaev & Nesterov (1992) and Dias et al. (2006). The Dias et al. (2006) value is dominated by large numbers of faint UCAC2 stars and likely suffers from a significant amount of field star contamination. As we (and most other studies) do not agree with the mean proper motion estimated by Dias et al. (2006), we do not use their membership probabilities.

#### 3.1.2. Revised High Mass Cluster Membership List

We now take the 61 probable and 16 possible cluster members from Claria et al. (2003) and further select those as members that meet the *combined* near-infrared and optical photometric and the proper motion criteria, i.e., those:

- lying near a dereddened isochrone on near-IR and optical CM and CC diagrams.
- with proper motions within two sigma of our derived cluster mean, and
- whose proper motion uncertainties are less than 5 mas/yr.

All of the Claria et al. (2003) objects were consistent with the photometric criterion. The second criterion was determined through a  $\chi^2$  comparison to the mean cluster motion (as measured in § 3.1.1 and presented in Table 1) which includes the objects' proper motion uncertainty along with an assumed intrinsic velocity dispersion of 1 mas/yr, where 1 mas/yr  $\approx 0.7$  km/s (Bevington & Robinson 1992). In equation form:

$$\chi^{2} = \left\{ \frac{\left[ \overline{(\mu_{\alpha} \cos \delta)^{\mathrm{cl}}} - (\mu_{\alpha} \cos \delta)^{*} \right]^{2}}{(\sigma_{\mathrm{int},\mu_{\alpha} \cos \delta}^{\mathrm{cl}})^{2} + (\sigma_{\mu_{\alpha} \cos \delta}^{*})^{2}} \right\} + \left\{ \frac{\left[ \overline{\mu_{\delta}^{\mathrm{cl}}} - \mu_{\delta}^{*} \right]^{2}}{(\sigma_{\mathrm{int},\mu_{\delta}}^{\mathrm{cl}})^{2} + (\sigma_{\mu_{\delta}}^{*})^{2}} \right\}$$
(1)

where the "cl" superscript designates the cluster, the "int" subscript designates intrinsic, and the asterisk superscript designates individual stars. By selecting those sources with  $\chi^2 \leq 6$ and two degrees of freedom, we expect only  $\approx 5\%$  of bona fide cluster members to be rejected using this criterion ( $\sim 2 \sigma$ ).

We invoke the last criterion to reduce the chances that sources with relatively large uncertainties may unjustifiably obtain low  $\chi^2$  values and contaminate our sample of bona fide cluster members. We selected a 5 mas/yr cutoff because it is less than the typical UCAC2 uncertainty for their faintest objects ( $V \gtrsim 12$ ). The consequence of this criterion, however, is that at the distance of IC 2395, spectral types inferred from *J-H* to be roughly later than mid-F are deselected. In our effort to reduce interlopers, we have potentially removed faint cluster members reducing both the sample size and mass range of a measured disk fraction. Incorporating later spectral types will require adding other criteria such as radial velocity, spectral classification, or youth spectral features (see §3.2).

Our proper motion criteria retained 40 of the Claria et al. (2003) sample of 61 probable cluster members. We examined the six sources that had  $\chi^2 \leq 6$  and uncertainties greater then 5 mas/yr and found that half of them had very inconsistent mean proper motions and were left deselected. The other three had mean proper motions within 1  $\sigma$  of the cluster mean ( $\chi^2 \leq 1$ ) and we reclassified them as possible cluster members. Another of the original 61 had no measured proper motion and was retained but only as a possible member. We also examined the sources that had  $\chi^2 \geq 6$  and uncertainties less than 5 mas/yr to identify any sources that were potentially penalized for having abnormally small reported uncertainties ( $\leq 2 \text{ mas/yr}$ ). Three were retained and reclassified as possible cluster members.

Of the original Claria et al. (2003) sample of 16 possible cluster members, three were proper motion selected and hence upgraded to probable members. One possible member had no measured proper motion and remains a possible member.

After having applied the additional membership criteria, we end up with 43 probable cluster members and 14 possible members. As we discuss below, we believe that two of the possible members are probable members, increasing the reported number to 45 cluster members and 12 possible members. In the following section, we discuss the selection of members from radial velocities measured from our spectra. In addition to allowing us to extend the membership list to lower masses, we apply this test to the possible massive members from Claria et al. (2003), eliminating a total of ten probable and possible members<sup>4</sup>.

## 3.2. Low mass member candidates from radial velocities

# 3.2.1. Radial Velocities

The result of our radial velocity survey is shown in Figure 4. the cluster members are clearly concentrated around 24.7 km s<sup>-1</sup> with  $\sigma = 1.54$  km s<sup>-1</sup>. We accepted an object as a cluster member if its radial velocity is within 2.4  $\sigma$  (= 1 full width at half maximum of the distribution) of the mean radial velocity<sup>5</sup>. Increasing this criterion to 3  $\sigma$  admits 17 additional sources, but nine are likely to be non-members, where we have estimated the number of non-members as the average for all velocities in the figure outside of 4  $\sigma$  from 24.7 km s<sup>-1</sup>. Increasing the window to 4  $\sigma$  admits a total of 46 additional stars, but by the same method we estimate that 24 are likely to be non-members. Close binaries will have discrepant velocities outside our adopted criterion for cluster membership and will be rejected on this basis; it appears that there are relatively few such cases, or extending the radial velocity selection threshold would add more probable members.

We also revised the high-mass membership of the proper motion members based on radial velocities, reducing the total size of this sample to 37 members and 10 possible members. The final selection of members from Claria et al. (2003) is listed in Table 2, while the full membership list including those from Table 2 is provided in Tables 3 and 4. Figure 6 places the members on CM and CC diagrams. Altogether we identified 250 low-mass members that were not included in the proper motion sample, based on our radial velocity survey.

# 3.2.2. Spectral Types

Spectral types were assigned as available from the literature, as indicated in Table 2. The U-B vs. B-V color-color diagram shows that the reddening is uniform across the region, such that the U-B vs. B-V sequence is well-defined and there are no obvious signs of spread (outside of expectations from the presence of binaries) (Claria et al. 2003). We estimated

<sup>&</sup>lt;sup>4</sup>However, the radial velocity selection criterion is biased against close massive binaries, so some of the eliminated stars may in fact be cluster members.

<sup>&</sup>lt;sup>5</sup>We relaxed the radial velocity requirement if the object appeared to be a member or possible member based on proper motion data. In this case we accepted a star as a member for the final analysis if its radial velocity was within 4.8  $\sigma$  of the mean radial velocity.

the  $E_{B-V}$  for the members with spectral types using the intrinsic main-sequence relation of Pecaut & Mamajek (2013). Reddening this sequence according to  $E_{U-B} = 0.73 * E_{B-V}$ , our estimate is  $E_{B-V}=0.09$  mag, as also found by Claria et al. (2003). We therefore adopt an extinction equivalent to  $E_{B-V} = 0.09$ .

Where types were unavailable, we used our photometry to estimate them. For the stars earlier than ~ K4 the preferred color for this purpose, V - J or V - K, depends on the age of the cluster and whether there is, for example, active accretion. V - K is the better choice for evolved field stars because of the longer wavelength baseline, whereas for very young star forming clusters V - J is preferred to circumvent excess emission at K. IC 2395 is in between. Therefore, before selecting the bands we did a number of tests. First, we computed trend lines of V vs. V - J and V - K. The scatter was similar (in all these evaluations, we rejected outliers in similar numbers -  $\sim 8\%$  - for both bands). However, when the scatter was weighted by the expected V - J or V - K value to create a metric for the uncertainty in stellar type that would result, the metric was a factor of 1.39 smaller for V-K. That is, the larger wavelength baseline resulted in a significant advantage for use of V-K. After identifying the Class II sources, we also tested whether K or IRAC1 (hereafter [3.6]) could be contaminated by excess emission. To do so, we took all of the Class II sources and compared their observed K - [3.6] colors with those we would expect from the spectral types we assigned them as discussed in the following paragraph and using the Luhman et al. (2010) standard colors for young stars. There were no significant discrepancies, and the average was -0.01, that is the K - [3.6] color was 0.01 bluer than expected for the standard colors.

Therefore, for types earlier than K4, we made the type estimates based on the (extinctioncorrected) V - K color compared with the tabulation in Mamajek (2015), while for K4 and later we used the J-[3.6] colors from Luhman et al. (2010). After a preliminary assignment of types, we determined empirical loci for the apparent V and [3.6] magnitudes vs. type. We rejected any type estimates for stars that deviated from these loci by more than 1.1 magnitudes in V or 0.8 magnitudes in [3.6]. That is, the types were only accepted if the stars were consistent in V - K or J-[3.6] and had apparent magnitudes consistent with cluster membership at both V and [3.6]. Of the 295 members, 80 failed the tests for a consistent classification, of which 13 are Class II sources (see below).

#### **3.3.** Age

We have put the age of the cluster on the revised age scale (e.g., Bell et al. 2013). To do so, we estimated the cluster age and distance from the Claria et al. (2003) catalog of

probable luminous members, using the Ekström et al. (2012) main-sequence interior models including the effects of rotation. Given that the photometry is in the apparent color-apparent magnitude plane, it is first necessary to transform the interior models into color-magnitude space and then also redden the model corresponding to E(B-V)=0.09 mag. To transform the interior models we used the Castelli & Kurucz (2004) so-called ODFnew models. To redden the model isochrones we used the standard  $A_V = 3.1 \times E(B-V)$  relation (as appropriate for the low level of reddening, see e.g. Olson (1975)). The most massive star, HD 74455, provides the best age diagnostic for this method. It sits in the vertical region of the model isochrones, hence the small dependencies of the estimated age on the color and reddening combined with the small reddening of the cluster itself will have an insignificant effect on the result. This star is a likely ellipsoidal variable (Morris 1985), i.e. a binary, but given the verticle isochrones the single-star luminosity for one of the pair is still compatible with our assigned age. Using main-sequence fitting, we estimated a distance modulus of ~ 9.5 mag (equivalent to ~ 800 pc; as also found by Claria et al.) and an age of ~ 9 Myr.

This age is confirmed by the V vs. V - J HR (CM) diagram in Figure 5, which is primarily based on the low-mass cluster members identified in our study. Both age determinations agree on ~ 9 Myr . As is usually the case, the revised calibration gives a significantly older age than the traditional estimate of  $6 \pm 2$  Myr (Claria et al. 2003).

IC 2395 is in an age range where absolute ages are not well-determined but relative ones are better understood (Soderblom et al. 2014). We assign an error of 3 Myr, i.e., we take the age to be  $9 \pm 3$  Myr. This error is to be understood as a statement that IC 2395 is likely to be similar in age to Upper Sco and Ori OB1b, nominally near 10 Myr (on the revised age scale), and neither so young as classic star-forming clusters such as  $\rho$  Oph, NGC1333, NGC 2244, or IC 348 nor so old as Ori OB1a and LCC/UCL. On the traditional age scale, these clusters/associations are in the same relative sequence, but all at younger ages.

### 4. Analysis

The key result of this section is the identification of candidate IC 2395 cluster members with evidence of circumstellar disks. *Spitzer* photometry is efficient in identifying evolutionary stages for disks around young stars (e.g. Allen et al. 2004; Megeath et al. 2004; Hartmann et al. 2005; Sicilia-Aguilar et al. 2006; Megeath et al. 2005; Lada et al. 2006; Allen et al. 2007; Wang & Looney 2007). For the youngest systems, these studies have distinguished deeply embedded protostars (Class I) from accreting T-Tauri-like stars (Class II) from "normal" stars (Class III), based on placement on IRAC CC diagrams (e.g. [3.6]-[4.5] versus [5.8]-[8.0]). We build on this body of experience to separate Class II sources from the nonor weak-excess Class III cluster members and to identify the transitional disks caught in the process of transformation between these classes. At the age of IC 2395, second-generation debris disks are also starting to appear - these are systems where the dust is not primordial, but is generated in planetesimal collisions.

We have matched the selected cluster members presented in Tables 2 and 3 to the IRAC and MIPS photometry using a 2.5" radial positional threshold. Several of the Claria et al. (2003) objects are outside the areas covered with IRAC and MIPS and a handful are incomplete in the IRAC detections. Altogether 277 objects out of 297 are detected in all 4 IRAC bands and 67 of those also have counterparts at 24  $\mu$ m. We use this body of photometry to identify the transitional, Class II, and strong debris disks in IC 2395. We find 18 Class II sources (6.5% of the sources detected in all four IRAC bands), 8 transitional disks (2.9% of the full IRAC detections) and 23 debris disk candidates (8.3%).

The most significant risk in using the longer wavelength *Spitzer* channels for identifying stars and protostars with strong infrared excess emission is contamination from thermal dust continuum from the residual natal molecular cloud, including emission from polycylic aromatic hydrocarbon molecules (PAHs, which contribute strongly at 8  $\mu$ m), and confusion with background sources along the line-of-sight. After identifying the cluster members with strong emission from circumstellar disks, we discuss the extent to which contamination may influence these results.

### 4.1. Identification of excess types among cluster members

Figures 6 and 7 show the objects with excesses on different optical-near-infrared-midinfrared CM and CC diagrams. The locations of the identified sources are also shown in Figure 2. Two objects (#6 and #21) that have large K – [24] excess are not classified because all of our classification schemes require IRAC data and these two stars are outside the area covered by IRAC. Based on their K – [24] color they can be either transitional disks or class II sources. The identification of the other objects is explained in the next three subsections. Since we will use identical criteria for a sample of 19 clusters and associations as listed in Table 6, we discuss our approach in this general context.

# 4.1.1. Transitional disks

Although it is desirable to identify transitional disks through infrared spectroscopy (Espaillat et al. 2014), our aim is for a large sample to investigate their incidence and how

it evolves with age. Since infrared spectroscopy is not available for all of this sample, we used photometry to test for photospheric-like colors in the 4  $\mu$ m region and to measure the size of the excess at 24  $\mu$ m, and also impose a requirement on the spectral type of the star for systems old enough that extreme debris disks might be confused with transitional ones.

We first derive a criterion to test for photospheric-like colors. We start with a simple physical definition, obtained from Sicilia-Aguilar et al. (2008): a transitional disk should have no excess out to 6  $\mu$ m, but should retain a large excess at 24  $\mu$ m, indicative of retention of much of the primordial disk in the more distant zone that dominates at this wavelength. In this regard, transitional disks can be distinguished from Class II sources, which have significant excesses already at 6  $\mu$ m (Sicilia-Aguilar et al. 2008). The simplest way to isolate candidate transitional disks, then, is to use a color difference involving IRAC band 3 at 5.8  $\mu$ m. We prefer [3.6] – [5.8] because we will want to apply identical criteria to many clusters and associations, some with significant reddening, and this color difference is significantly less affected by extinction than is the case for color differences involving shorter wavelengths, such as K (e.g., Flaherty et al. 2007). In addition, the measurements of [3.6] and [5.8] are obtained at the same time and hence are not affected by variability.

To determine the acceptable values of [3.6] - [5.8] to isolate candidate transitional disks from Class II sources, we show in Figure 8 the distribution of this color difference for our entire sample of stellar clusters and associations (listed in Table 6), along with a Gaussian fit to the primary peak in the distribution. There is a distinct excess over the Gaussian fit for sources with [3.6] - [5.8] < 0.4. We adopt this value as the limit for a candidate transitional disk since it defines a class of object that apparently does not belong to the population of typical Class II YSOs. The  $K - [6\mu m]$  slope quoted as the upper limit for transitional disks by Kim et al. (2013) predicts this same color, while the limits by Espaillat et al. (2014) and Muzerolle et al. (2010) are more lenient, equivalent respectively to [3.6] - [5.8] = 0.48and 0.56.

In the cases of Upper Sco, Lower Centaurus Crux (LCC), Upper Centaurus Lupus (UCL), and TW Hya, we have identified transitional disks from WISE photometry. To determine a criterion similar to that we have adopted for IRAC photometry, we compared W1 - W2 vs. [3.6] - [5.8] for more than 100 sources with measurements in both systems in Upper Sco, finding that the equivalent limit is W1 - W2 < 0.43 with a nominal error of 0.01.

We also need to define a minimum level of excess at 24  $\mu$ m. Muzerolle et al. (2010) define "weak excess" transitional disks with a slope equivalent to [8] - [24]  $\geq$  1.5. They also define an optically thick disk with a slope roughly equivalent to [8] - [24] = 3.5. We adopt a threshold of [8] - [24] = 1.5 and compare our results at this level with those at [8] - [24]

> 2.5 and [8] - [24]  $> 3.5^6$ . To determine similar criteria for measurements with WISE, we used measurements of sources in Upper Sco detected in both sets of photometry to set the equivalent threshold to be W3 - W4 > 0.8 and W2 - W4 > 1.7.

A question remains of whether the *Spitzer* measurements should also put a limit on how strong the source infrared excess can be at IRAC4 (8  $\mu$ m). We explored the implications of strong fluxes in this band using the YSO disk SED fitting tool (Robitaille et al. 2006) and found that disks with masses and accretion rates well within the range expected for transitional disks (e.g., disk masses of ~  $10^{-6}M_{\odot}$  and accretion <  $10^{-10}M_{\odot}$  yr<sup>-1</sup>) could have substantial fluxes at 8  $\mu$ m. In addition, the broad IRAC 8  $\mu$ m band can include silicate emission, which can be strong in transitional disks. Therefore, we imposed no requirement there.

Finally, we imposed a spectral type criterion. The great majority of transitional disks are around stars of spectral type later than F (Muzerolle et al. 2010; Espaillat et al. 2014). The evolution of protoplanetary disks is faster around higher mass stars (e.g., Kennedy & Kenyon 2009; Yasui et al. 2014). Therefore, by an age of ~ 10 Myr, we do not expect to find many transitional disks around early-type stars. To reflect this trend, we imposed the requirement that the stellar spectral type for ages > 6 Myr had to be later than F (either from spectroscopy or estimated through photometry) to accept a disk as being transitional. The transitional disks in IC 2395 resulting from these criteria are indicated in Table 5 (WT for weak transitional, [8] – [24] < 2.5, and T for transitional). Our final selection criteria are also illustrated in Figure 8.

To test the degree of debris-disk contamination in these selections, we used the list of ten extreme debris systems in Balog et al. (2009) (we excluded HD 21362 since its excess is dominated by free-free emission). These sources have excesses at 24  $\mu$ m by at least a factor of four (i.e., 1.5 magnitudes, the threshold for our identifying a weak transitional disk) and hence can be compared directly with our candidate transitional disks, since the latter are required to have similar excesses. We used the identical approaches with these sources, first testing with *Spitzer* [3.6] – [5.8] photometry (from Balog et al. (2009); Gorlova et al. (2007); Weinberger et al. (2011)) and if that was lacking, using WISE measurements. Two of the extreme debris systems are too red in these colors to pass our transitional disk criterion; if we also impose the spectral type criterion, *only* BD 20 307 would pass our selection. Only HR 4796A has [8] - [24] > 2.5, but it is too early-type to pass our criteria. Therefore, the potential contamination appears to be small, particularly at the higher thresholds for 24

<sup>&</sup>lt;sup>6</sup>For comparison, Cieza et al. (2012) use a roughly similar threshold of [3.6] - [24] = 1.5 to identify candidate transitional disks.

 $\mu$ m excess. If the [8] - [24] > 1.5 threshold were allowing a significant number of extreme debris disks, we would expect the fraction of transitional disk candidates to decrease as the threshold was increased, but Table 6 shows that, if anything, there is a trend in the opposite direction. We conclude that, at least for the samples  $\leq 15$  Myr in age, debris-disk contamination is not an issue.

### 4.1.2. Class II Objects

Class II objects are pre-main sequence stars characterized by SEDs with photospheric emission at visible wavelengths up to about  $2\,\mu$ m followed by flat or gradually decreasing slopes at longer wavelengths (e.g. Lada & Wilking 1984; Lada 1987). The mid-infrared emission is believed to be due to large amounts of heated dust dispersed in an optically-thick, gas-rich primordial disk. In some cases, there may also be an ultraviolet excess component of the SED indicating radiation emitted from an accretion shock on the star's surface (Muzerolle et al. 2003). Class II includes classic T Tauri stars (CTTSs) and Herbig AeBe (HAeBe) stars. Their existence within a cluster, especially in large numbers, implies stellar ages on the traditional scale of less than about 10 Myr (e.g. Haisch et al. 2001; Mamajek 2005; Hillenbrand 2005). Stars older than this age have typically dissipated their primordial gas (e.g. Pascucci et al. 2006) so that any thermal dust emission is optically thin.

Our criteria for identifying transitional disks join consistently onto the criteria for photometric identification of Class II sources from Gutermuth et al. (2009), which are: [3.6] - [5.8] > 0.4 and  $[4.5] - [8] > 0.268 \times ([3.6] - [5.8]) + 0.393$ . We also required a detection at 22 or 24  $\mu$ m. These objects are designated II in Table 5.

#### 4.1.3. Debris Disks

Debris disks represent the final evolutionary state of circumstellar disks. By this stage, the primordial gas has fully dissipated and impacts among the planetesimals create a collisional cascade, resulting in a dusty, gas-less disk. When heated by the central star, the dust reradiates in the mid-infrared. Stars in IC 2395 with [8] - [24] > 0.15 and spectral type of F or earlier or [8] - [24] < 1.5 and of later spectral type were designated debris disks (D in Table 5). If no spectral type could be assigned photometrically (and none was available spectroscopically), we designate the status in Table 5 as D?. Sources 8 and 15 are two marginal cases with [8] - [24] = 0.15 at significance levels of 5 and 3.4  $\sigma$ , respectively. We have not included them in Table 5, but their parameters can be recovered from Tables 3 and 4 if desired. We identified 23 debris disk candidates. A number of the debris disk candidates have modest (0.15 - 0.30 magnitudes) IRAC band excesses at 8  $\mu$ m.

### 4.2. Contamination

The most likely contaminant in our identification of stars with 24  $\mu$ m excesses is confusion from random line-of-sight positional overlap with distant optically-faint but infraredbright galaxies, planetary nebulae, and AGN. The effects of these contaminations are usually small (Megeath et al. 2004; Gutermuth et al. 2008). For example, with  $\sim$ 2000 extra-galactic  $24 \ \mu m$  sources per square degree at  $0.5 \ mJy$  (Papovich et al. 2004), for a flux less than our completeness limit but greater than our detection limit, the probability of a chance background source observed within our matching radius of 2.5'' of any single cluster member is  $0.3\% \left[ \pi (2.5''^2/(3600^2)) \times 2000 \right]$  which means that in our sample of almost 300 stars the probability of one chance alignment is close to 100%, but more than a few cases is unlikely. We examined the angular offsets between the 2MASS and the IRAC and MIPS positions of our candidate IR excess stars to evaluate whether their excesses can be attributed to chance alignment. We found that the average offset between the 2MASS and IRAC coordinates is about  $0.3'' \pm 0.3''$  with a maximum separation of 0.68''. That is, the probability of a chance alignment with a 2MASS source is around 1%. For the objects with MIPS photometry, we found that the average offset between the 2MASS and MIPS coordinates is  $0.5'' \pm 0.5''$ with a large portion of the error coming from a few sources where the distance is larger than 1". These are member candidate Nos. 37, 219, 44, 82, 198, 242, 230, and 122, with offsets respectively of 2.25", 1.58", 1.49", 1.38", 1.11", 1.10", 1.03", and 1.02" (without these sources the average error is  $0.4'' \pm 0.3''$  with no significant offset). Given the errors, an offset for a single source of 1'' is plausible while an offset of 1.5'' is unlikely but still possible; any larger offset is probably a chance alignment. Therefore, we removed star No. 37 from the sample of infrared excess sources (although its identification as a cluster member is still valid). We visually examined the images of Nos. 219, 44, and 82 and found that No. 82 is close to a bright star in an area of relatively large background confusion, also indicated by its large measurement errors; it also was removed from the infrared excess sample. No. 219 has no obvious background contamination and shows a large excess even in the IRAC bands which makes it unlikely to be a spurious detection. We are left with No. 44 as the only ambiguous candidate. However, this star is on well-behaved background, so we have accepted it. To summarize, we found two IR excess candidates (Nos. 37 and 82) that are probably contaminated, and we removed them in the final analysis.

### 5. Discussion: Place of Transitional Disks in Disk Evolution

IC 2395 includes a large proportion of transitional disks. Transitional disks were first identified from IRAS data as a class with little or no excess emission at wavelengths short of 10  $\mu$ m, indicating little dust close to the star, but with strong excesses at longer wavelengths indicative of an optically thick outer disk (Strom et al. 1989). Multiple interpretations have been advanced for this behavior (Williams & Cieza 2011). Previous studies have invoked the presence of a planet (Rice et al. 2003; Quillen et al. 2004), dust evolution (Wilner et al. 2005), or photoevaporation (Hollenbach et al. 2000; Alexander et al. 2006; Goto et al. 2006) to explain the observed "holes".

With the end of the *Spitzer* and WISE cryogenic missions, and publication of nearly all the cluster observations obtained with them, the pace of finding major new samples of transitional disks will slow substantially, making an update of their behavior timely. The most recent work along the same lines (Espaillat et al. 2014) utilized Upper Sco as its oldest sample, but since then questions have been raised about the age of the low-mass members of this moving group (Herczeg & Hillenbrand 2015) that may undermine it as a probe of 11-Myr-old transitional disks. IC 2395 (and other stellar clusters/associations of similar age) can provide a critical independent estimate. In the following four paragraphs, we set the scene for this analysis by discussing age scales, and then sample selection. In the next section we show that, in general, the proportion of transitional disks does not change dramatically from one cluster/association to another of similar age. This conclusion justifies our averaging of the transitional disk proportions in the following section, to derive highweight proportions of transitional disks in young and middle-aged clusters/associations (1 -3.5 and 4 - 6.5 Myr respectively on the tradional calibration, 1 - 6 and 8 - 13 Myr on the revised one).

We will focus on the young stellar clusters and associations listed in Table 6, for which we show ages on both the revised and the traditional calibrations. Because ages on the traditional calibration have been determined in a variety of ways, in obtaining a homogeneous set we have given priority to those selected in the review by Eric Mamajek (Mamajek 2009). Where ages on the revised calibration are not available directly, we have assigned them according to similarity in published HR diagrams for clusters/associations with directly determined ages. These cases are indicated in the notes to the table. As a test of this procedure, we evaluated Ori OB1b, which according to the HR diagram from Hernández et al. (2008), should have an age similar to those of  $\lambda$  Ori, NGC 2362, and  $\gamma$  Vel, all of which are indicated to be 10 - 12 Myr on the revised scale. We took the measurements of low-mass members of Ori OB1b from Briceño et al. (2005), adjusted them to the distance of IC 2395, and applied extinction corrections to the individual stars according to the estimates of this parameter in Briceño et al. (2005). We then superimposed the resulting V vs. V-J diagram on the one for IC 2395 shown in Figure 5. The agreement is excellent indicating an age of  $\sim$ 9 Myr for Ori OB1b, although there is more scatter for the stars in it, presumably because of the complications introduced by the larger and variable extinction. This agreement supports the age assignment on the revised calibration.

Importantly for this study, both the traditional and revised age calibrations place the cluster/associations into age groupings identically, as shown in Table 6. Therefore, our conclusions about the behavior of transitional disks will only change in timescale with a change in age calibration, but otherwise will remain identical.

A critical issue is how, in each case, to define a sample of cluster members for study. The most conservative approach is to require that the members be identified through techniques *not* involving the mid-infrared (to avoid any possibility of introducing a bias into the infrared characteristics we use to identify transitional disks). We have applied the same criteria for transitional and Class II disks as discussed above for IC 2395. Table 6 lists the ratios of transitional to (transitional + Class II) disks for each stellar cluster or association. It also shows the totals for three age ranges: 1 - 6 Myr, 8 - 13 Myr, and 14 - 17 Myr (all on the revised calibration, corresponding to 1 - 3.5, 4 - 6.5, and 7 - 16 Myr on the traditional calibration). For the young clusters within 1 kpc, the totals extend down to moderately late type, low mass stars, while for the two more distant young clusters (NGC 2244 and 2362), the infrared measurements extend down only to intermediate mass stars. Therefore, we also show the totals omitting the two distant clusters. These values are in boldface because we believe them to be the most reliable indicators of transitional disk behavior. We show similar boldface numbers for the intermediate age range, but both groupings in the oldest age range are closer than 1 kpc.

A less-conservative approach uses the *Spitzer* data to identify cluster members, yielding significantly larger numbers in the samples. The results with this approach are also tabulated for the youngest age range<sup>7</sup>; for the intermediate and old ranges, the cluster members are all identified without Spitzer data so this case is not shown. The results for all three levels of conservatism are identical within the errors, indicating that they are relatively robust to the member-identification approach.

<sup>&</sup>lt;sup>7</sup>We do not show the values for the individual clusters.

# 5.1. Does the Proportion of Transitional Disks Vary from Cluster to Cluster?

Table 6 shows that, in general, the individual clusters/associations in the young ( $\leq$  6 Myr on the revised scale) and middle-aged (8 - 13 Myr) categories have incidences of transitional disks consistent within the errors with the averages for each group (in particular, Upper Sco seems to be in line with other clusters and associations of similar age). This is also true for the old category, but in that case with very minimal counts. To make this comparison quantitative, we use the difference from the average in units of the quoted errors for all the young and middle-aged systems. The result is a nearly perfect normal distribution, except that the number of transitional disks in  $\rho$  Oph is low at 2/123 or 1.6%. Turning to the infrared-selected sample, this cluster is still low in transitional disks, 9/249 or 3.6%, but now at less than  $3\sigma$  from the average. That is, there is no compelling evidence for variations in the fraction of transitional disks over the full set of results reported in Table 6, although the case of  $\rho$  Oph deserves further investigation.

Sicilia-Aguilar et al. (2008) have reported that the Coronet Cluster may have an abnormally high incidence of transitional disks, and indeed the counts reported for it in Table 6 are higher than average, albeit not at a statistically significant level. To understand any possible differences, we examine the seven transitional disks identified by Sicilia-Aguilar et al. (2008) in more detail. Only two of these disks are within the selection criteria for our sample - CrA-4111 and G-14. A third source on their list, G-65, has no data at 24  $\mu$ m (Table 3 of Sicilia-Aguilar et al. (2008)) and furthermore has a [3.6] - [5.8] color of 1.01, far larger than our selection threshold of < 0.4. Two more sources from their list, CrA-466 and G-87, also have large values of [3.6] - [5.8], 0.81 and 0.72 respectively. Two more from their list, CrA-205 and CrA-4109, are missing IRAC data used in our photometric selection; extrapolating from the existing data, they would likely be classified as transitional disks if full IRAC measurements were available. We do not add them to our sample because a similar detailed examination has not been performed for all the other clusters. However, we have included one source, G-30, which they excluded because of low signal to noise at 24  $\mu m$  (the indicated SNR of 6.7 puts it above our WT threshold by ~ 1 $\sigma$ ; excluding it would introduce a potential bias in our method). If we added the two sources with missing IRAC data without subtracting the one with a low SNR, it would not raise the apparent excess of transitional disks to a statistically significant level. It is necessary to add three additional disks to the three we have identified to barely reach a 2- $\sigma$  result. We conclude that the Coronet cluster does not provide a convincing counter-example to our conclusion that the incidence of transitional disks is *not* variable for stellar groupings of similar age, within the limits of the existing data.

# 5.2. Change of Transitional Disk Proportion with Age

The results of the preceding section suggest that we can use the average incidences of transitional disks for young, middle-aged, and elderly systems without significant loss of information. There is a substantial and highly statistically significant increase in the fraction of transitional disks among those disks with strong 24  $\mu$ m excesses, going from the young to the middle-aged clusters/associations; the elderly clusters/associations have an incidence perhaps similar to that for the middle-aged ones, but the low numbers in the elderly grouping make any firm conclusions impossible. Figure 10 shows this trend graphically. The trend of an increasing incidence of transitional disks with age has been found previously, e.g., Muzerolle et al. (2010), but with marginal statistical significance for the older clusters/associations, and by Currie & Sicilia-Aguilar (2011), again with sparse representation of older clusters/associations, and with the results summarized in the review by Espaillat et al. (2014). This trend is put on a firm statistical basis by the average results for the young and middle-aged stellar clusters/assocations summarized in Table 6. In general, other studies using different criteria for identifying transitional disks will find them in different numbers (see cautions in Espaillat et al. (2014)), but our study remains valid in terms of trends because it uses a homogeneous selection throughout.

What are the implications of the substantial change in transitional disks as a fraction of strong-infrared-excess disks? There are two limiting possibilities: 1.) that there is a systematic change in disk properties with age that is reflected by an increasing probability of any given disk entering this stage; or 2.) that the disks retain similar structures but there is an increasing fraction of those remaining at any time that enters the transitional stage. An indication that the second case is closer to correct is that the relative fractions of disks with [8] - [24] > 1.5, 2.5, or 3.5 is virtually identical for the averages for the young and middle-aged stellar groupings, i.e., 1:  $0.98 \pm 0.21$ :  $1.78 \pm 0.42$  and 1:  $0.93 \pm 0.34$ :  $1.35 \pm 0.28$ , respectively (based on the boldfaced values in Table 6). Since the excess at 24  $\mu$ m is an indicator for the optical depth of the disks outside the inner few AU, these statistics indicate that a minority of systems can retain disks that are still very dense in this zone for 10 Myr or a bit longer.

We therefore assume that the time to clear an optically thick disk is independent of the age of the stellar grouping to which it belongs, and that such clearing passes through a transitional disk stage, which is of similar duration for all disks (e.g., Muzerolle et al. 2010; Espaillat et al. 2014). The consequence of the increase in transitional disk incidence is then that the decay of the 24- $\mu$ m-dominant optically thick disk component of a YSO population cannot be exponential, unlike that at shorter infrared wavelengths (e.g., Ribas et al. 2014), but must start slowly and accelerate relative to an exponential.

# 6. Conclusions

The open cluster IC 2395 can add significantly to our understanding of protoplanetary and early debris disk evolution, since it is relatively close (800 pc) and at a critical age where protoplanetary disks are disappearing and debris disks begin to dominate. However, the cluster has largely been overlooked in disk studies. We report optical and infrared photometry and high resolution optical spectroscopy of the cluster, from which we:

- Increase the list of probable members to nearly 300, spanning spectral types of early B to middle M;
- Estimate an age of  $9 \pm 3$  Myr on the revised age scale, e.g. that of Bell et al. (2013); this value compares with  $6 \pm 2$  Myr on the traditional scale (Claria et al. 2003); and
- Identify 18 Class II (6.5% of the members with full IRAC data), 8 transitional disk (2.9%), and 23 debris disk candidates (8.3%).

We have combined the transitional disk information with homogeneously defined similar objects in nineteen additional young clusters and associations to quantify the evolution of this phase; finding that

- The dominant cause of variations in the proportion of transitional disks is age; most clusters of similar age have similar proportions of transitional disks among the systems with strong 24  $\mu$ m excesses. The single possible exception is  $\rho$  Oph, where transitional disks are relatively rare.
- The relative numbers of disks with different degrees of 24  $\mu$ m excess do not change significantly with age, implying that the change in the proportion of transitional disks is not driven by a systematic change of disk properties, e.g., a thinning of disks that makes them more susceptible to dissipation
- The number of disks in the transitional phase as a fraction of the total with strong 24 μm excesses ([8] [24] ≥ 1.5) increases from 8.4 ± 1.3% at ~ 3 Myr to 46 ± 5% at ~ 10 Myr; alternative definitions of transitional disks will yield different percentages but should show the same trend.
- Under the conventional assumption that the lifetime of the transitional stage is fixed, and given the evidence that the nature of the individual Class II and transitional disks does not change with age, this result implies that the decay in the proportion of systems with strong 24  $\mu$ m excesses cannot be exponential, but must start more slowly and finish more rapidly than the "best fit" exponential.

We have also demonstrated that IC 2395 is a rich cluster at a critical age for circumstellar disk evolution, worthy of additional study.

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Table 1.Proper Motion Studies of IC 2395

Survey	$\mu_{lpha} \cos \delta$ mas/yr	Uncertainty mas/yr	$\mu_{\delta} \ { m mas/yr}$	Uncertainty mas/yr	Sample size	Comments
Gulyaev & Nesterov (1992)	+2.3	1.0	-1.8	1.0	8	Greater then $3\sigma$ away from this paper's result.
Baumgardt et al. (2000)	-3.6	0.6	2.2	0.5	1	
Dias et al. (2001)	-4.4	1.6	4.0	1.6	11	
Dias et al. (2002)	-4.37	1.73	4.05	1.73	14	
Loktin et al. (2003)	-4.86	0.33	3.48	0.23	33	
Kharchenko et al. (2003)	-4.21	0.63	1.73	0.63	12	
Kharchenko et al. (2004)	-4.34	0.38	2.42	0.35	15	
Dias et al. (2006)	-5.56	0.40	6.02	0.40	55	Greater then $3\sigma$ away from this paper's result.
This Paper	-3.92	0.33	3.03	0.26	11	1 clipped; proper motion values used in this analysis.
This Paper	-3.60	0.36	2.69	0.28	10	2 clipped

$ID^{a}$	ID					V	B-V	uncosó	11.5	Other
12	Tbl 4 <sup>b</sup>	BA (2000)	Dec (2000)	$S_{D}T$	Ref.	(mag)	(mag)	(mas/vr)	(mas/vr)	Designation <sup>c</sup>
	-	- ( /				( - 0)	(	( 1757	( 1757	
246	1	8:40:09.9	-48:07:57.6	A5V	1	11.29	0.10	$-3.4\pm2.9$	$4.2 \pm 3.8$	-
232	2	8:40:18.9	-48:29:43.4	A7V	1	11.30	0.16	$-8.1\pm1.4$	$5.7 \pm 1.4$	CD-484010
229	3	8:40:25.6	-48:22:48.1	F7	3	12.96	0.56	$-13.7\pm5.8$	$12.7 \pm 5.8$	-
113	14	8:40:46.8	-48:12:42.8	B8:	2	9.60	0.05	$-8.7\pm3.0$	$-1.6 \pm 3.0$	JW8, CD-474208
112	16	8:40:48.2	-48:14:15.6	A4	3	11.75	0.17	$-6.1 \pm 2.3$	$2.0 \pm 3.2$	JW5, CD-474209
111	23	8:40:53.4	-48:13:31.8	B2IV	2	6.96	-0.16	$-3.6\pm0.6$	$2.2 \pm 0.4$	JW2, HD74234
260	-	8:40:59.8	-47:47:02.8	FOII	1	11.39	0.17	$-4.6 \pm 2.1$	$3.9 \pm 2.0$	CD-474211
118	36	8:41:04.0	-48:04:15.6	F9	3	13.31	0.61	$6.6 \pm 5.1$	$5.8 \pm 5.1$	-
119	41	8:41:13.7	-48:04:36.7	F'5	3	12.77	0.49	$-7.2\pm3.6$	$1.5 \pm 1.4$	-
100	45	8:41:19.2	-48:13:04.2	DODY	5	14.32	0.68			-
128	-	8:41:30.4	-47:58:41.5	BOIV	2	9.92	-0.04	$-1.2\pm2.1$	$6.7 \pm 1.3$	L57,HD74338
129	_	8:41:35.3	-47:57:51.3	AI	3	11.12	0.09	$-2.4 \pm 1.9$	$2.4 \pm 1.4$	CD-474225
50	60	8:41:35.8	-48:04:24.1	A3 Co	3	11.30	0.12	$-2.9\pm3.0$	$0.5 \pm 1.4$	L54
220	63	8:41:37.3	-48:20:47.8	G2	3	13.03	0.64	$-8.0\pm 0.8$	7.2±5.8	-
41	77	8:41:44.9	-48:09:35.8	FO	3	12.17	0.38	$-4.6 \pm 2.2$	$2.2 \pm 1.4$	L51 L50
40	83	8:41:50.5	-48:09:17.6	FO	3	13.20	0.45	$1.7 \pm 3.0$	-1.(±2.(	L50
39	92	8:41:55.2	-48:09:12.2	A3 DO (AOM	3	11.49	0.15	$-6.0\pm1.4$	$4.4 \pm 1.4$	CD-474238
266	96	8:41:55.7	-47:52:12.6	B9/AUV	2	9.84	-0.02	$-4.9\pm1.7$	$5.1 \pm 1.8$	HD74402
263	107	8:41:59.5	-47:48:17.7	B9V	1	10.29	-0.05	$-4.6 \pm 1.3$	$3.4 \pm 1.5$	CD-474240
18	114	8:42:04.9	-48:11:43.3	A3 Doll	3	11.88	0.17	$-4.3 \pm 1.4$	$5.5 \pm 2.3$	L49
83	121	8:42:07.5	-48:14:40.9	B3V	2	8.23	-0.06	$-4.1\pm1.2$	$4.4 \pm 1.5$	L6, HD74436 <sup>-4</sup>
80	122	8:42:08.2	-48:13:16.5	F7	3	13.12	0.58	$-6.1\pm5.8$	$2.8 \pm 5.8$	-
216	124	8:42:09.5	-48:20:56.1	F3 D0	3	12.68	0.44	$-4.9\pm5.8$	8.1±5.8	- I 42 CD 474047
5	131	8:42:11.8	-48:06:33.0	B9:	2	10.39	0.00	$-3.4\pm1.4$	$4.7\pm2.0$	L43,CD-474247
38	137	8:42:12.9	-48:09:34.5	GI	3	13.60	0.66			- CDD 479576 I 44
0	138	8:42:14.3	-48:06:55.9	B9 D5V	3	11.28	0.09	$-4.4 \pm 1.4$	$4.0 \pm 1.4$	CPD-472576, L44
211	139	8:42:14.4	-48:27:09.2	BSV	2	9.46	-0.04	$-1.5 \pm 1.7$	$0.8 \pm 1.2$	HD74456
2	142	8:42:15.8	-48:04:20.0	A5	3	11.70	0.29	-2.2±3.2	$5.3 \pm 2.4$	
1	143	8:42:16.2	-48:05:56.7	B1.5Vn	2	5.49	-0.18	$-3.8\pm0.9$	$2.7 \pm 0.8$	HD74455 , V" HA Vel
3	148	8:42:17.8	-48:03:53.1	B9V	4	10.74	0.03	$-0.8\pm2.5$	$1.1 \pm 1.4$	L15, CD-474253
135	171	8:42:20.4	-47:58:22.1	A0 E0	3	12.49	0.32	$-4.0\pm1.4$	7.2±1.0	L20
ۍ م مح	180	8:42:30.1	-47:59:17.9	F 9	3	13.29	0.63	$-7.0\pm2.7$	8.7±2.5	-
30	188	8:42:33.5	-48:10:27.8	A4 DOV.	3	11.91	0.22	$-5.9\pm2.3$	$0.9\pm2.3$	-
126	102	0:42:34.0	-46:09:46.9	D2V:	2	11.02	-0.16	$-3.7 \pm 0.8$	$2.9\pm0.7$	CD 474960
130	195	0:42:30.2	-47:00:47.4	DO DOIN N	3	9.71	0.00	$-0.4\pm1.7$	$3.7 \pm 1.4$	CD-474260
10	195	8:42:30.3	-48:04:30.9	D31V-V D9	2	0.71	-0.11	$-3.3\pm1.7$ 0.4 $\pm$ 2.7	$4.4\pm1.0$	L8, HD74550
10	109	8.42.30.0	48.08.19.2	10	3	11.56	0.03	-9.4_2.1	47117	L34, CD-474202
205	200	8:42:37.0	-46:06:12.5	AU C1	3 9	11.00	0.12	-0.3±2.0	4.7±1.7 1 0±5 0	L28, CD-474204
205	207	8.42.39.3	48.05.17.0	45	2	11.07	0.08	-0.3±3.8	-1.0±0.0	- I 22 CD 474265
20	207	8:42:42.1	-48:05:17.0	AD A1	3 9	11.07	0.13	-0.1±1.1 85±0.7	$1.3 \pm 1.4$ 5 4 $\pm 1.7$	L35,CD-474205
24	200	8.42.42.4	48.00.27.2	AI	2	11.17	0.10	$-6.5 \pm 2.7$	5.4⊥1.7 4.6⊥1.4	L31, CD-474200
141	209	8.42.43.0	47.51.02.5	F6	2	12.60	0.12	$-4.0\pm1.0$ 0.2 $\pm2.5$	$4.0 \pm 1.4$ 6 1 $\pm 2.2$	L29, CD-474207
141	212	8.42.44.5	49.05.95 5	POV-	0	12.09	0.49	$-9.5 \pm 2.5$	$0.1 \pm 2.2$	-
21	-	0:42:40.4	-46:00:20.0	D9Ve E4	2	9.49	-0.03	$-2.3\pm1.3$	$1.7 \pm 1.7$	L11, HD74559
29	220	8:42:47.2	-48:08:04.2	F4 DC/NV	3	12.69	0.54	$-9.1\pm 0.1$	$13.3 \pm 0.1$	L20
73	221	0:42:47.9	-48:13:31.9	D0/8V	2	9.25	-0.09	$-4.3\pm1.3$	1.9±1.9	L21, HD74581
74 21	222	0:42:40.0	-46:15:40.4	D/A D2V	2	9.93	0.02	$-4.0\pm1.3$	$-1.9\pm2.4$	-
31 79	220	8:42:00.2	-48:07:41.2	D3V D7V	4	10.42	-0.03	$-1.0 \pm 1.4$ 5 0 ± 1 2	$3.0 \pm 1.2$	L14 CD 474974
70	242	0.40:00.2	-40.13:00.0	Dev	4	2 01	-0.02	-0.9±1.3	4.0±1.3 5.1±0.7	L14, UD-4/42/4
269	255	0:40:04.0 8.13.06 K	-40:11:00.7	DOV C6	2	0.91	-0.04	-0.0±0.9	0.1±0.7 5.3±5.0	13, 11D/4021
200	200	0.40:00.0 8.43.10 0	-40.10:10.2	B31/	ა ი	9 97	0.70	-0.9±0.9 5 7±1 9	0.0±0.8 9.6±1.1	- HD74662
202	277	8.43.20.1	40.20:42.9	1 DOV	2	0.07	-0.11	$-5.7 \pm 1.3$	2.0±1.1 3.1±1.5	CD 474986
175	211	0.40:29.1	40.02:04.9	E 2	о 9	10.99	0.04	-4.0±1.4	0.1±1.0 0.6±0.6	01-414200
162	283 287	0:43:41.3	-40:09:33.1	г 3 А 7 V	3 1	12.84	0.48	-0.9±2.9	2.0±2.0	- CD 474208
100	201	0:44:07.8	-40:01:14.0	AIV E°	1	12.00	0.18	-4.9±1.8	4.4±4.8	0D-4/4298
102	200	0:44:11.4 8:11:26 6	-40:10:44.4	го 45111	э 1	11.64	0.02	-0.0±0.8 6 3±1 4	1.1±0.8 7 5±3 9	- CD 474307
194	-	0.44.20.0	-40.21.00.1	AJIII	1	11.04	0.24	-0.5 1.4	1.5±5.5	00-414001

Table 2. General Characteristics of IC 2395 Cluster Members from Claria et al. (2003)

<sup>a</sup>From Claria et al. (2003)

 $^{\mathrm{b}}\mathrm{If}$  no cross-reference to Table 4 is provided, we do not confirm the membership assignment.

 $^{\rm c}{\rm CD}$  or CPD = photographic plates from the Annals of the Cape Observatory, L = Lynga, HD = Henry Draper

<sup>d</sup>Probable binary

 $^{\rm e}$  Likely ellipsoidal variable (Morris  $\,$  1985), hence binary

Note. — (i) Celestial coordinates are from 2MASS; (ii) optical photometry from Claria et al. (2003); uncertainties described therein; (iii) proper motions from NOMAD; Zacharias et al. (2004); (iv) mean cluster proper motion derived in §3.1.1 is  $\mu_{\alpha}\cos\delta = -3.9\pm0.4 \text{ mas/yr}$  and  $\mu_{\delta} = 3.0\pm0.4 \text{ mas/yr}$ . Spectral type references: 1, Pickles & Depagne (2010); 2, Skiff (2014); 3, from photometry (see text); 4, from H $\beta$  photometry (Paunzen 2015) calibrated through (Crawford & Mander 1966).

Cluster Members	
$\operatorname{of}$	
Photometry	
Optical	
Table 3.	

(err) (mag)	I	I	Ι	I	0.022	0.029	0.013	0.014	0.01	0.008	0.01	0.006	0.007	0.012	0.008	0.037	0.018	0.012	0.007	0.01	0.017	0.015	0.086	0.012	0.014	0.006	0.013	0.009	0.016	0.005	0.01	210.0	0.012	0.013	0.008	0.014	0.007	0.011	0.013	0.005	0.011	0.008	0.006	0.005	0.006	0.009	0.005	0.01
I (mag)	I	I	I	Ι	14.41	16.566	14.822	10.903	15.25	16.485	16.3	15.235	12.606	9.357	11.371	11.351	16.481	14.045	13.457	16.579	15.241	16.857	6.725	17.2	16.581	15.857	15.383	16.305	16.562	15.624	16.036	13.505	15.212 15 561	16.465	12.545	15.634	15.815	11.41	16.552	12.034	15.717	14.265	15.541	13.471	15.598	16.737	15.228	15.803
(err) (mag)	I	I	I	I	0.012	0.016	0.015	0.011	0.007	0.013	0.013	0.007	0.008	0.013	0.008	0.039	0.018	0.017	0.007	0.015	0.007	0.015	I	0.019	0.017	0.008	0.01	0.009	0.019	0.008	0.007	0.006	170.0	0.012	0.008	0.008	0.009	0.008	0.01	0.005	0.01	0.007	0.008	0.005	0.009	0.011	0.008	0.011
R (mag)	I	I	I	Ι	15.122	18.143	15.777	11.098	16.484	17.964	17.682	16.357	13.09	9.412	11.581	11.477	17.931	14.719	14.044	18.071	16.572	18.431	I	19.055	18.405	17.109	16.689	17.878	18.141	17.066	17.387	19.04	16.01 16.61	17.958	12.895	17.1	17.033	11.552	17.986	12.323	16.85	14.941	16.989	13.906	16.837	18.509	16.473	17.376
(err) (mag)	I	I	I	I	0.011	0.036	0.008	0.011	0.013	0.024	0.019	0.01	0.006	0.024	0.005	0.025	0.03	0.014	0.007	0.02	0.008	0.037	0.101	0.058	0.041	0.014	0.015	0.023	0.038	0.013	0.021	0.00 0.07	0.00	0.022	0.005	0.017	0.013	0.006	0.028	0.006	0.017	0.006	0.012	0.005	0.01	0.039	0.008	0.027
V (mag)	11 114	11.116	12.783	I	15.836	19.652	16.791	11.285	17.594	19.25	18.862	17.398	13.623	9.493	11.824	11.768	19.122	15.487	14.699	19.315	17.756	19.717	7.631	20.657	19.93	18.217	17.84	19.186	19.444	18.267	18.525	14.619 90.415	17 603	19.193	13.282	18.303	18.157	11.685	19.184	12.641	17.96	15.698	18.201	14.337	17.951	19.91	17.568	18.723
(err) (mag)	I	I	I	I	0.009	Ι	0.013	0.005	0.026	I	0.078	0.02	0.003	0.023	0.003	0.072	I	0.013	0.004	I	0.028	I	0.2	I	I	0.048	0.029	Ι	I	0.05	0.046	GUU.U	0.026		0.005	0.032	0.038	0.013	Ι	0.004	0.032	0.007	0.039	0.004	0.033	I	0.023	0.067
B (mag)	11 251	11.32	13.381	I	17.052	Ι	18.233	11.591	19.158	I	20.278	18.96	14.502	9.556	12.232	12.255	I	16.683	15.783	I	19.266	I	7.677	I	I	19.848	19.429	Ι	I	19.854	20.049	129.61		се <u>п</u> ет	13.944	19.877	19.72	11.851	I	13.173	19.514	16.949	19.828	15.026	19.601	I	19.027	20.451
(err) (mag)	I	I	I	I	0.014	Ι	0.058	0.015	I	I	I	I	0.002	0.028	0.006	0.035	I	0.021	0.006	ļ	I	I	0.061	I	I	I	ļ	Ι	I	0.158		GUU.U			0.003	0.099	Ι	0.006	I	0.003	I	0.012	0.124	0.003	I	I	I	I
U mag	11 463	11.602	13.549	I	17.685	Ι	19.469	11.835	I	I	I	I	14.968	9.272	12.633	11.972	I	17.796	16.493	ļ	I	I	5.942	I	I	I	ļ	Ι	I	20.751		16.332			14.159	20.63	Ι	11.62	I	13.316	I	18.049	20.797	15.237	I	I	I	I
$_{\rm SpT^a}$	A 1	41 41	F7	Ι	K8	M7	M0	A8	I	M6	I	I	$_{\rm K0}$	I	F1	A4	I	K8	K4	M4	M4	I	I	I	M6	M3	I	M6	M6	M4	M3	K3		M4	F9	M6	M0	A4	I	F5	M0	K5	M6	I	M1	M6	L	M6
DEC(2000) (deg)	-48 13267	-48.49538	-48.38002	-48.15396	-48.35785	-47.80875	-48.08578	-47.97556	-47.97577	-47.89005	-48.13	-47.92146	-48.09262	-48.21189	-47.95963	-48.23767	-48.0119	-47.85571	-47.93254	-48.12297	-47.82916	-48.30987	-48.22551	-48.39803	-47.89508	-48.04948	-47.89904	-48.08591	-47.88766	-48.22288	-48.27729	-48.00943	47 00615	-48.39655	-48.07101	-48.31279	-48.05354	-48.24735	-48.30906	-48.07686	-47.85229	-48.07088	-47.94247	-48.21782	-48.01932	-47.91004	-48.11476	-47.80632
m RA(2000) (deg)	130 04111	130.07856	130.10667	130.13353	130.16329	130.16755	130.17279	130.17401	130.18154	130.18426	130.19016	130.19292	130.19294	130.19516	130.19645	130.20083	130.20201	130.2088	130.21083	130.21435	130.21711	130.22224	130.2225	130.225	130.22738	130.23338	130.23468	130.23669	130.24285	130.24851	130.24887	130.24976	120.25013	130.2598	130.26646	130.28096	130.29027	130.29346	130.30281	130.3069	130.3076	130.31617	130.32777	130.33013	130.33425	130.34054	130.35021	130.35659
<u>а</u>	-	• 6	ı က	4	ŋ	9	7	œ	6	10	11	12	13	14	15	16	17	18	19	20	21	$^{22}$	23	$^{24}$	25	26	27	$^{28}$	29	30	31	2 2 2	0 c	# <u>1</u> 2	36	37	38	39	40	41	$^{42}$	43	44	45	46	47	$^{48}$	49

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$\mathbf{C}$	
0   	
Table	

Ð	m RA(2000) (deg)	DEC(2000) (deg)	$_{\rm SpT^a}$	U mag	(err) (mag)	B (mag)	(err) $(mag)$	V (mag)	(err) (mag)	${ m R}$ (mag)	(err) $(mag)$	I (mag)	(err) $(mag)$
51	130.36452	-47.93229	K7	19.054	0.026	17.6	0.00	16.244	0.008	15.403	0.007	14.714	0.007
52	130.36982	-48.0752	M4	I	I	19.358	0.033	17.827	0.01	16.763	0.005	15.597	0.005
53	130.37517	-48.17687	M6	I	I	I	Ι	18.725	0.019	17.5	0.009	16.141	0.006
54	130.38432	-48.06913	M6	I	I	I	I	19.121	0.029	17.705	0.012	16.032	0.007
55	130.385	-47.87392	M6	I	I	20.715	0.085	19.193	0.024	17.927	0.018	16.442	0.008
56	130.38717	-48.02066	M4	I	L	20.048	0.056	18.567	0.019	17.358	0.01	15.893	0.006
57	130.38908	-48.24433		16.735	0.006	16.042	0.006	15.043	0.01	14.428	0.008	13.863	0.011
0 0 0 0	130.39047 130.39047	-48.00595 -48.18454	M3	1 1	1 1	- 20.083	- 0.050	18.254 18.571	0.012	17.095	0.008	15.744	0.006
60	130.39926	-48.07337	A3	11.501	0.004	11.286	200.0	11.111	0.009	11.055	0.01	10.965	0.012
61	130.40133	-48.09466			*		-	19.588	0.034	18.293	0.013	16.714	0.009
62	130.40297	-48.16009	I	19.328	0.039	18.257	0.013	16.797	0.007	15.837	0.006	14.88	0.006
63	130.40549	-48.34661	$G_2$	13.738	0.003	13.557	0.006	12.894	0.009	12.499	0.009	12.139	0.008
64	130.4077	-47.93177	M6	I	I	20.146	0.054	18.631	0.019	17.447	0.01	16.069	0.006
65	130.40883	-47.97562	M6	I	I	19.502	0.032	18.001	0.016	16.845	0.007	15.572	0.008
99	130.40947	-47.80299	M6		- 0	20.795	0.104	19.125	0.021	17.727	0.008	16.022	0.007
2.0	130.41169	-47.91742 47.05945	2.5	14.021	0.003	13.431	0.003	12.025 90.110	0.0050	12.189	0.015	16.074	0.000
69	130 41879	01206.11-	MG			20.139	0.061	18.556	0.016	17.359	110.0	15,939	10.0
20	130.42058	-48.32122	K5	17.677	0.008	16.673	0.004	15.462	0.006	14.72	0.009	14.042	0.012
71	130.42212	-47.92717	I	18.83	0.024	17.495	0.008	16.104	0.008	15.219	0.01	14.403	0.007
72	130.42264	-48.04642	M5	I	I	20.012	0.055	18.496	0.015	17.321	0.009	15.957	0.007
73	130.43183	-48.06353	M6	I	I	ļ	I	19.745	0.038	18.395	0.015	16.712	0.008
74	130.43366	-48.09705	$G_{6}$	14.116	0.002	13.676	0.004	12.906	0.004	12.426	0.005	11.97	0.006
75	130.43452	-48.03746	M6	I	I	20.746	0.106	19.238	0.022	17.942	0.01	16.375	0.01
76	130.43642	-48.07252	M6	I	I	19.967	0.049	18.443	0.017	17.189	0.008	15.638	0.007
77	130.43713	-48.15996	F0	12.7	0.006	12.415	0.012	12.001	0.006	11.792	0.012	11.562	0.007
18	130.43779	-48.24184	K5	16.984	0.005	16.163	0.004	15.123	0.004	14.49	0.009	13.859	0.017
67	130.43919	-48.01921	7.IVI	19.070	0.047	67.9T	610.0	10.788 20.614	000.0	10.007	0.0070	14.014	100.0
0 2	130.44319	-48.33692	MS			- 20-116	0.053	18 559	0.018	12.09/	0.019	16.011	0.013
82	130.45622	-48.12308		I	I			20.327	0.075	18.964	0.027	17.227	0.014
83	130.4606	-48.15488	F6	13.598	0.003	13.465	0.004	13.043	0.005	12.741	0.005	12.418	0.005
$^{84}$	130.46658	-48.19344	M6	I	Ι	I	I	19.167	0.025	17.665	0.008	15.928	0.007
85	130.46871	-48.12927	M0	I	I	19.577	0.039	18.1	0.014	16.882	0.009	15.468	0.005
86	130.46939	-48.14062	M4	I	I	19.194	0.029	17.671	0.009	16.568	0.005	15.386	0.005
87	130.47019	-47.97116	L	L	L	20.323	0.049	18.893	0.024	17.681	0.008	16.229	0.008
80	130.47197	-47.98656	K4	16.866	0.009	15.999	0.006	14.921	0.009	14.268	0.005	13.655	0.004
89	130.47275	-47.88406	K5	19.186	0.026	18.118	0.014	16.731	0.013	15.836	0.01	14.995	0.011
06	130.47304	-48.37222	M3	I	I	19.637	0.04	18.064	0.015	16.917	0.009	15.636	0.011
91	130.47504	-48.29206	M5			20.597	0.079	18.873	0.022	17.637	0.012	16.161	0.012
92	130.48015	-48.15339	A3	11.659	0.007	11.486	0.009	11.308	0.006	11.217	0.009	11.084	0.012
93	130.48058	-47.91023	M6	I	I	20.317	0.066	18.594	0.016	17.348	0.009	15.944	0.005
94 7	130.4814	10102.14-	0 IVI		1 0	19.724	0.047	18.130	10.0	1/.UUS	0.008	10.8U3	c.uu
95	130.482	-47.92538	I F	17.883	0.011	16.639 0.045	0.007	15.335	0.01	14.504	0.017	13.771	0.02
96 0	130.48222	-47.87016	B7	9.784	0.007	9.647	0.008	9.65	0.008	9.623	0.014	9.626	0.011
76	130.48235	-48.11474	- 3	18.678	0.02	17.402	0.007	16.077	0.005	15.241	0.003	14.505	0.003
80	130.48289	-47.98434	IW	I	I	20.097	0.054	18.504	0.02	17.325	0.011	15.949	0.006
66 1 0 0 1	130.48379	-47.93894	M6	I	I	I	I	19.502	0.038	18.182	0.016	16.627	0.01
TUU	130.48392	-48.23105	M16	I	I	I	I	19.44	0.034	18.120	0.014	16.509	0.008

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Table	

	${ m RA}(2000)$	DEC(2000)		n	(err)	в	(err)	>	(err)	R	(err)	Ι	(err)
9	(deg)	(deg)	$_{\rm SpT^a}$	mag	(mag)	(mag)	(mag)	(mag)	(mag)	(mag)	(mag)	(mag)	(mag)
101	130.48719	-48.27705	$\mathbf{K5}$	17.141	0.005	16.165	0.005	15.092	0.01	14.44	0.006	13.819	0.009
102	130.48939	-47.88853	M6	I	I	I	I	19.335	0.036	17.902	0.013	16.208	0.009
103	130.4914	-48.03883	K7	19.642	0.037	18.336	0.02	16.89	0.012	15.983	0.016	15.141	0.013
104	130.49318	-47.84533	K5	18.067	0.011	16.566	0.005	15.242	0.006	14.476	0.003	13.829	0.004
105	130.49445	-48.25725	K5	19.095	0.038	17.409	0.006	16.058	0.007	15.201	0.004	14.402	0.008
106	130.49729	-47.99005	M5	I	I	20.006	0.046	18.48	0.02	17.204	0.009	15.644	0.007
107	130.49802	-47.80492	B5	10.317	0.009	10.053	0.004	10.08	0.007	10.03	0.009	10.044	0.012
108	130.4981	-48.28121	K7	18.146	0.009	16.653	0.007	15.275	0.01	14.419	0.006	13.661	0.007
109	130.49969	-48.29562	I	I	I	I	I	20.399	0.078	18.871	0.016	17.218	0.014
110	130.50042	-48.012	I	I	I	I	I	I	I	I	I	I	I
111	130.50084	-48.086	M6	I	I	20.374	0.043	18.751	0.02	17.558	0.011	16.129	0.007
112	130.50467	-48.00283	M6	I	I	21.318	0.119	19.493	0.032	18.197	0.033	16.558	0.028
113	130.52028	-48.06779	M4	I	I	20.334	0.04	18.884	0.017	17.611	0.013	16.087	0.007
114	130.52043	-48.19535	A3	12.105	0.004	11.902	0.002	11.678	0.008	11.596	0.02	11.462	0.008
115	130.52097	-47.79497	M6	I	I	20.953	0.124	19.201	0.026	17.885	0.017	16.404	0.02
116	130.52116	-48.10053	M5	I	I	I	I	19.445	0.023	18.154	0.015	16.575	0.011
117	130.52117	-48.12712	M6	20.906	0.113	19.807	0.025	18.174	0.014	16.92	0.009	15.402	0.006
118	130.52257	-47.90689	I	I	I	I	I	20.794	0.115	19.274	0.026	17.41	0.012
119	130.52434	-48.0064	I	I	I	I	I	17.783	0.014	16.601	0.019	15.087	0.038
120	130.52733	-48.27716	M6	I	I	I	I	19.985	0.052	18.421	0.013	16.571	0.011
121	130.53145	-48.24471	I	7.952	0.01	8.244	0.055	9.827	0.263	9.155	0.098	8.171	0.028
122	130.53398	-48.22125	F7	13.784	0.005	13.553	0.007	12.945	0.003	12.59	0.011	12.259	0.009
123	130.53875	-48.20716	I	ļ	I	I	I	20.625	0.07	19.118	0.024	17.354	0.013
124	130.53961	-48.34891	F3	13.115	0.007	12.992	0.007	12.523	12.628	12.235	0.005	11.973	0.006
125	130.54101	-48.13182	M6	I	I	I	I	19.792	0.045	18.451	0.021	16.782	0.008
126	130.54268	-48.09797	M5	I	I	20.69	0.122	18.754	0.02	17.499	0.011	16.066	0.008
127	130.54306	-47.78288	M5	I	I	20.165	0.049	18.57	0.017	17.33	0.017	15.93	0.018
128	130.54515	-47.82073	M6	I	I	20.425	0.064	18.827	0.019	17.541	0.008	16.053	0.007
129	130.54864	-48.1435	I	18.636	0.016	17.493	0.007	16.193	0.008	15.352	0.008	14.544	0.008
130	130.54883	-48.01179	I	19.999	0.046	20.079	0.039	18.918	0.018	17.641	0.013	16.063	0.014
131	130.54911	-48.10916	A0	10.205	0.003	10.233	0.005	10.196	0.005	10.162	0.005	10.146	0.008
132	130.54935	-48.35825	I	18.162	0.015	16.908	0.008	15.456	15.561	14.522	0.005	13.609	0.006
133	130.55006	-48.24302	I	I	I	I	I	I	I	I	I	I	I
134	130.55077	-47.93385	M6	ļ	I	19.945	0.06	18.404	0.043	17.101	0.042	15.577	0.064
135	130.5535	-48.08714	I	16.434	0.005	15.672	0.004	14.61	0.007	13.95	0.006	13.304	0.005
136	130.55352	-48.22897	Ι.;	I	I	I	I	19.722	0.037	18.403	0.017	16.788	0.014
137	130.55393	-48.15959	5	14.349	0.003	14.125	0.005	13.474	0.008	13.054	0.008	12.676	0.007
138	130.55945	-48.11552	6 <b>H</b>	11.391	0.004	11.211	0.006	11.081	0.005	11.029	0.006	10.975	0.01
139	130.56005	-48.45256	I	9.019	0.017	9.319	0.016	9.327	0.018	9.308	0.02	9.28	0.024
140	130.5623	-48.13295	I	I	I	I	I	20.001	0.043	18.577	0.019	16.937	0.011
141	130.5624	-47.80244	M5	I	L	19.997	0.041	18.537	0.035	17.207	0.031	15.678	0.043
142	130.56567	-48.07223	A5	12.079	0.006	11.8	0.004	11.502	0.004	11.329	0.008	11.18	0.007
143	130.56747	-48.09907	I	I	I	I	I	8.32	0.119	7.877	0.117	7.074	0.124
144	130.56877	-47.78455	M0	18.929	0.023	17.56	0.008	16.213	0.012	15.368	0.014	14.644	0.014
145	130.56956	-48.02019	M1	I	I	19.547	0.024	17.98	0.012	16.849	0.01	15.59	0.008
146	130.56967	-48.15525	M5	I	I	20.717	0.082	19.117	0.021	17.75	0.013	16.085	0.008
147	130.57163	-48.24849	M7	I	I	I	I	20.625	20.73	19.175	0.018	17.338	0.01
148	130.57428	-48.06475	B9	10.648	0.002	10.579	0.005	10.52	0.003	10.482	0.007	10.469	0.008
149	130.57547	-48.05382	M6	1	1		1	19.355	0.031	17.96	0.013	16.194	0.007
150	130.57648	-48.16748	$M_2$	19.661	0.03	18.282	0.011	16.798	0.01	15.802	0.01	14.87	0.006

Table 3—Continued

	DEC(2000) (deg)	$S_{D}T^{a}$	U mag	(err) (mag)	B (mag)	(err) (mag)	V (mag)	(err) (mag)	R (mag)	(err) (mag)	I (mag)	(err) (mag)
(gan)		T do	Spill	(Spin)	(gpm)	(Spirit)	(gpm)	(Spirit)	(and)	(gpm)	(Spm)	(Spirit)
-48.1368	с С	G8	14.412	0.004	14.011	0.005	13.18	0.004	12.676	0.01	12.213	0.007
-47.8036	7	I	16.676	0.005	15.7	0.005	14.373	0.005	13.55	0.004	12.802	0.005
-48.1755	6	I	21.844	0.276	21.298	0.112	19.767	0.031	18.402	0.018	16.767	0.01
-48.1027	4	M6	I	I	20.458	0.048	19.076	0.023	17.696	0.016	16.049	0.011
-48.1200	4	L	I	I	I	I	20.676	0.083	19.065	0.028	17.073	0.013
-48.3560	- 1	M4	20.777	0.12	19.63	0.035	17.956	18.061	16.74	0.009	15.279	0.012
-48.3374	<u>م</u>	M16	I	I	0	1 0	19.89	19.995 0.010	18.549	0.012	16.9 	0.014
-48.0779	9	M6	I	I	19.934	0.03	18.362	0.016	17.172	0.012	15.769	0.009
-48.003	4	I	I	I	1	1	1.99.02	0.069	18.807	0.022	17.142	0.013
-48.0499	2			L	19.413	0.021	17.849	0.013	16.675	0.011	15.324	0.008
-48.1873		M0	19.731	0.037	18.598	0.016	17.138	0.012	16.15	0.014	15.142	0.011
-48.4284	5	K8	18.822	0.028	17.51	0.01	16.111	16.216	15.245	0.009	14.469	0.011
-48.0153	5 C	M0	19.135	0.018	17.829	0.01	16.419	0.006	15.508	0.007	14.662	0.007
-48.0430	2	M6	I	I	I	I	19.34	0.028	18.078	0.017	16.487	0.009
-48.2171	6	I	I	I	I	I	19.781	0.036	18.479	0.02	16.835	0.01
-48.2724	4	I	I	Ι	Ι	I	Ι	I	I	I	I	I
-48.192	0	M6	I	I	19.768	0.031	18.214	0.016	17.05	0.012	15.707	0.007
-48.1561	1	M4	20.813	0.084	19.802	0.031	18.182	0.014	17.034	0.01	15.707	0.007
-48.2981	9	M6	I	I	I	I	19.839	19.944	18.457	0.014	16.808	0.011
-48.3623	35	I	20.368	0.115	19.234	0.029	17.681	17.786	16.59	0.007	15.427	0.009
-47.972	x	A6	12.919	0.007	12.589	0.007	12.259	0.006	12.056	0.01	11.862	0.006
-48.069	11	M5	20.945	0.113	20.021	0.034	18.413	0.014	17.188	0.011	15.762	0.011
-48.149	57	I	I	I	I	I	20.451	0.053	19.017	0.023	17.215	0.013
-48.126	66	M5	20.724	0.088	19.403	0.023	17.859	0.01	16.788	0.009	15.598	0.007
-48.177	45	I	14.822	0.011	14.113	0.014	13.091	0.02	12.473	0.034	11.919	0.027
-48.232	33	I	I	I	I	I	19.439	0.032	18.147	0.011	16.628	0.01
-47.933	93	I	I	I	I	I	20.068	0.05	18.663	0.021	17.052	0.009
-48.155	51	K3	16.475	0.004	15.685	0.004	14.644	0.005	14.011	0.005	13.447	0.005
-48.325	54	I	Ι	I	I	I	20.183	20.288	18.652	0.013	16.874	0.01
-47.988	ņ	F9	13.989	0.003	13.71	0.003	13.1	0.008	12.689	0.005	12.315	0.007
-48.009	60	M6	I	I	I	I	19.802	0.037	18.432	0.014	16.772	0.009
-48.376	38	M6	I	I	I	I	19.421	19.526	17.869	0.009	16.021	0.01
-48.140	66	I	20.39	0.057	19.555	0.029	17.951	0.017	16.682	0.02	15.19	0.018
-48.156	95	M6	I	I	I	I	18.983	0.019	17.672	0.011	16.202	0.007
-48.05	1	M2	20.283	0.049	19.247	0.019	17.713	0.012	16.537	0.013	15.178	0.007
-48.220	33	M6	I	I	19.971	0.032	18.349	0.014	17.153	0.008	15.806	0.007
-48.266	08	I.	I	I	I	I	19.287	19.392	18.062	0.013	16.64	0.007
-48.174	39	A4	12.188	0.006	11.955	0.007	11.709	0.005	11.589	0.006	11.458	0.007
-48.213	14	I	I	I	20.751	0.06	19.477	0.027	18.173	0.01	16.559	0.007
-48.3369	92	M6	I	I	I	I	19.977	20.082	18.634	0.016	16.908	0.008
-48.166	92	F1	12.25	0.008	12.057	0.008	11.62	0.004	11.353	0.005	11.108	0.008
-48.3639	93	K1	15.658	0.007	15.075	0.007	14.119	14.224	13.556	0.008	13.069	0.01
-47.9298	34	B8	11.05	0.006	10.869	0.01	10.769	0.011	10.713	0.013	10.675	0.01
-48.061	96	M4	I	I	20.038	0.036	18.494	0.014	17.282	0.01	15.902	0.007
-48.075	24	B2	8.048	0.004	8.439	0.028	8.504	0.01	8.653	0.069	8.6	0.008
-48.288′	75	K0	15.341	0.007	14.769	0.008	13.829	13.934	13.288	0.007	12.823	0.009
-48.133	72	K6	17.622	0.007	16.545	0.005	15.305	0.008	14.549	0.007	13.883	0.006
-48.084	47	B8	10.564	0.003	10.48	0.004	10.409	0.005	10.374	0.006	10.362	0.008
-48.1025	60	II.	19.069	0.017	17.801	0.008	16.429	0.008	15.515	0.007	14.626	0.006
-48.1367	S	AU	11.734	0.004	11.496	0.003	11.332	0.005	11.269	0.004	11.209	0.009

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Table	

Ð	m RA(2000) $( m deg)$	DEC(2000) (deg)	$_{\rm SpT^a}$	U mag	(err) $(mag)$	$^{\mathrm{B}}$ (mag)	(err) $(mag)$	v (mag)	(err) $(mag)$	${ m R}$ (mag)	(err) $(mag)$	I (mag)	(err) (mag)
201	130.6573	-48.21142	I	19.303	0.025	18.048	0.011	16.588	0.005	15.657	0.005	14.753	0.004
202	130.65844	-47.99303	M6	20.773	0.07	21.129	0.083	19.639	0.033	18.143	0.024	16.421	0.007
203	130.66161	-48.05106	I	20.694	0.073	19.563	0.026	17.991	0.012	16.771	0.01	15.33	0.008
204	130.66723	-48.18991	I	20.826	0.086	19.704	0.024	18.049	0.012	16.906	0.01	15.619	0.006
205	130.67026	-48.30506	M6	I	I			19.246	19.351	17.922	200.0	16.386	0.007
206	130.67482	-48.09828	M4		1 0	20.127	0.029	18.616	0.016	17.406	0.011	15.979	0.008
202	130.67538 130.6754	-48.08806	45 MG		0.003	070.11 20.663	0.010	10.897	0.005	17.057	0.01	16.466	0.00
209	130.67932	-48.13215	AD AD	11.667	0.005	11.443	0.004	11.295	0.006	11.227	0.005	11.181	0.011
210	130.68044	-48.3464	K4	15.972	0.004	15.532	0.007	14.648	14.753	14.057	0.005	13.48	0.005
211	130.68077	-48.07929	M6	I	I	20.596	0.061	19.072	0.018	17.772	0.01	16.279	0.007
212	130.6855	-47.8507	F6	13.242	0.007	12.998	0.005	12.484	0.009	12.12	0.009	11.814	0.008
213	130.68681	-48.01668	I	19.858	0.035	20.203	0.035	18.971	0.019	17.65	0.014	16.023	0.006
214	130.6886	-48.15538	M5	I	I	19.749	0.027	18.145	0.014	16.989	0.007	15.688	0.006
215	130.68983	-48.08909	I	19.244	0.061	18.487	0.02	17.028	0.009	15.923	0.006	14.797	0.007
216	130.69152	-48.18824	M5	I	I	I	I	19.939	0.037	18.507	0.017	16.794	0.009
217	130.69166	-48.15731	M6	I	I	20.441	0.044	18.829	0.022	17.567	0.009	16.06	0.008
218	130.69378	-48.21757	K4	18.874	0.017	17.68	0.007	16.252	0.004	15.3	0.006	14.298	0.006
219	130.69404	-48.27368	M6	I	L	I	I	111.61	19.216	17.779	0.043	16.151	0.049
220	130.69659	-48.13451	F4	13.209	0.004	13.021	0.005	12.485	0.007	12.155	0.008	11.851	0.006
221	130.69967	-48.22552	B3	8.538	0.012	8.936	0.018	9.008	0.004	9.002	0.011	9.027	0.015
222	130.69981	-48.2279	B7	9.795	0.014	9.77	0.018	9.719	0.003	9.693	0.007	9.654	0.019
223	130.70182	-48.25902	I	19.427	0.027	18.083	0.013	16.687	16.792	15.803	0.006	14.961	0.008
224	130.70532	-47.98901	M3	I	I	19.466	0.033	17.976	0.015	16.944	0.007	15.972	0.007
225	130.70785	-48.23628	M6	I	I	20.045	0.034	18.53	0.016	17.259	0.008	15.686	0.008
226	130.71111	-48.10315	L	20.033	0.041	19.117	0.022	17.579	0.007	16.418	0.008	15.107	0.005
227	130.71711	-48.21714	M2		1	19.43	0.022	17.855	0.01	16.666	0.006	15.269	0.006
228	130.7211	-48.1281	I	8.165	0.003	8.42	0.019	8.444	0.007	8.354	0.046	8.428	0.012
229	130.72409	-48.2766	M6	I	I	19.942	0.051	18.353	18.458	17.143	0.007	15.786	0.01
230	130.72669	-48.14452	M6	19.927	0.033	20.077	0.029	18.85	0.02	17.54	0.011	15.928	0.007
731	120.72088	-48.40444	M3	- 17		670.02	0.004	18.532	18.037 0.007	17.371	0.007	10.124	0.009
707	61/7/001	-40.10049 48.00800	$\Gamma^4$	076.1T	0.000	10.046	0.000	40.01	0.000	14.040	enn.n	14.050 17 11 4	100.0
780	130.73867	-40.20039	ME		100.0	19.240	610.0	400.11	0.011	17 785	0.000	16.260	0.0076
101	130.73349	-48 24763	Ma			10 576	0.000	17 993	18,008	16.0	0.006	15 709	0.005
236	130.73568	-48.16783	M6	21.016	0.077	20.188	0.04	18.681	0.021	17.411	0.015	15.884	0.009
237	130.73768	-48.10828	I	I	I	I	I	19.636	0.034	18.335	0.018	16.679	0.01
238	130.73799	-48.14174	M5	I	I	20.701	0.058	19.104	0.02	17.804	0.014	16.311	0.007
239	130.74118	-48.08785	M4	ļ	ļ	I	I	19.172	0.024	17.822	0.012	16.297	0.009
240	130.74316	-48.22264	Ι	20.611	0.055	20.307	0.041	18.792	0.018	17.465	0.01	15.861	0.009
241	130.74466	-48.41864	I	20.406	0.086	19.248	0.022	17.784	17.889	16.701	0.008	15.447	0.012
$^{242}$	130.75099	-48.2185	B8	10.091	0.009	10.209	0.007	10.186	0.006	10.156	0.006	10.113	0.01
$^{243}$	130.75645	-48.18456	M5	I	I	20.411	0.043	18.864	0.019	17.584	0.009	16.112	0.006
244	130.75672	-47.83584	M2	19.79	0.031	18.412	0.012	16.921	0.009	15.901	0.008	14.935	0.008
$^{245}$	130.75759	-48.40117	Ι	I	I	I	I	19.386	19.491	18.049	0.011	16.478	0.007
$^{246}$	130.75851	-48.24496	M5	I	I	19.91	0.055	18.334	18.439	17.075	0.007	15.578	0.004
247	130.75894	-48.27816	M6	I	I	19.9	0.05	18.415	18.52	17.255	0.011	15.914	0.012
248	130.75929	-48.14733	M5	I	I	1 0		18.951	0.024	17.728	0.01	16.22	0.008
249	130.75979	-48.29715	M5	I	I	20.346	0.085	18.867	18.972	17.589	0.01	16.154	0.011
250	130.76245	-48.09072	M6	I	I	I	I	19.851	0.032	18.447	0.014	16.779	0.011

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	RA(2000)	DEC(2000)		D	(err)	n,	(err)	>	(err)	н Ч	(err)	1	(err)
e	(deg)	(deg)	$SpT^{a}$	mag	(mag)	(mag)	(mag)	(mag)	(mag)	(mag)	(mag)	(mag)	(mag)
251	130.76506	-47.98093	M4	20.072	0.055	19.006	0.018	17.465	0.011	16.321	0.008	15.019	0.007
252	130.76669	-47.90915	M6	I	I	I	I	19.899	0.045	18.296	0.012	16.512	0.008
253	130.76926	-48.19912	F4	12.337	0.006	12.131	0.006	11.61	0.005	11.281	0.004	10.963	0.006
254	130.77305	-48.21655	M5	I	I	20.515	0.051	19.049	0.023	17.523	0.01	15.683	0.006
255	130.77715	-48.3045	$G_{6}$	15.265	0.004	14.894	0.005	14.187	14.292	13.733	0.008	13.286	0.013
256	130.77866	-47.99617	M6	Ι	I	I	I	19.37	0.04	17.905	0.04	16.45	0.019
257	130.77901	-48.24989	Ι	I	I	I	I	20.465	20.57	19.096	0.015	17.287	0.011
258	130.79416	-48.41302	I	I	I	ļ	I	20.486	20.591	18.736	0.015	17.032	0.009
259	130.79544	-47.92458	M3	I	I	19.986	0.044	18.398	0.016	17.109	0.009	15.699	0.009
260	130.79786	-48.1705	M4	20.905	0.072	19.949	0.03	18.47	0.016	17.268	0.009	15.905	0.005
261	130.79973	-48.16979	M0	20.359	0.05	19.259	0.017	17.672	0.006	16.557	0.008	15.27	0.005
262	130.8083	-47.88947	K1	15.425	0.025	15.092	0.019	14.372	0.014	13.844	0.018	13.377	0.022
263	130.81026	-47.88939	A1	10.325	0.017	10.474	0.023	10.387	0.018	10.377	0.032	10.254	0.03
264	130.81077	-47.91597	M5	I	I	I	I	19.007	0.027	17.687	0.015	16.033	0.019
265	130.8125	-48.25545	M6	I	I	I	I	19.135	19.24	17.83	0.007	16.29	0.007
266	130.81962	-47.98082	M6	Ι	I	I	I	19.991	0.056	18.615	0.019	16.916	0.014
267	130.82009	-48.16689	M5	20.814	0.064	19.315	0.017	17.724	0.009	16.626	0.007	15.447	0.005
268	130.82298	-47.86301	G7	14.804	0.004	14.252	0.004	13.367	0.007	12.914	0.007	12.498	0.01
269	130.8235	-48.30886	Ι	Ι	I	I	I	19.031	19.136	17.792	0.012	16.235	0.011
270	130.83251	-48.18364	M6	I	I	I	I	20.213	0.052	18.774	0.023	16.998	0.015
271	130.8433	-47.89883	K2	16.214	0.006	15.601	0.004	14.609	0.005	14.07	0.005	13.555	0.007
272	130.84862	-48.12332	K4	17.945	0.009	16.616	0.005	15.384	0.004	14.617	0.006	13.973	0.006
273	130.85428	-48.09275	M5	I	I	I	I	18.299	0.016	17.134	0.007	15.783	0.013
274	130.85686	-47.96414	K6	17.353	0.008	16.553	0.007	15.322	0.008	14.639	0.007	13.952	0.009
275	130.8602	-48.3569	I	11.919	0.004	11.751	0.004	11.273	0.015	10.991	0.012	10.706	0.012
276	130.86751	-48.25191	I	18.073	0.016	16.682	0.009	15.223	0.006	14.339	0.004	13.5	0.006
277	130.87107	-48.04859	A1	11.024	I	10.893	I	10.809	I	I	I	I	I
278	130.87289	-48.0782	M3	I	I	18.656	0.024	17.104	0.007	16.003	0.007	14.737	0.011
279	130.89333	-48.21946	M6	I	I	I	I	20.073	0.068	18.77	0.024	17.066	0.01
280	130.90405	-47.93553	M1	I	I	19.233	0.028	17.663	0.011	16.631	0.005	15.399	0.009
281	130.90883	-48.14464	K4	16.85	0.01	15.84	0.005	14.723	0.008	14.041	0.006	13.434	0.008
282	130.91268	-48.21247	M5	I	I	20.014	0.042	18.499	0.018	17.303	0.009	15.879	0.008
283	130.92262	-48.15919	F3	13.358	0.005	13.109	0.004	12.61	0.006	12.299	0.005	11.995	0.007
284	130.94884	-47.88982	M2	I	I	19.895	0.041	18.367	0.014	17.236	0.008	15.892	0.008
285	130.96059	-48.26624	I	16.245	0.005	15.266	0.004	14.043	0.008	13.362	0.006	12.691	0.008
286	131.00331	-48.13297	M6	I	I	I	I	20.115	0.07	18.556	0.015	16.694	0.012
287	131.03263	-48.02072	A7	12.221	0.068	11.957	0.011	11.767	0.01	11.588	0.02	11.422	0.015
288	131.04764	-48.17899	F8	13.829	0.007	13.513	0.005	12.882	0.008	12.496	0.009	12.129	0.014
289	131.05665	-48.32706	F9	13.575	0.006	13.326	0.005	12.721	0.01	12.37	0.013	11.995	0.018
290	131.09737	-48.25454	I	17.707	0.012	16.23	0.005	14.806	0.008	13.985	0.01	13.196	0.011
291	131.10527	-48.19339	M6	I	I	I	I	19.863	0.058	18.386	0.017	16.716	0.014
292	131.10828	-48.09993	$G_2$	14.197	0.004	13.612	0.004	12.965	0.007	12.534	0.007	12.08	0.01
293	131.12079	-48.1723	I	18.009	0.021	16.724	0.009	15.258	0.01	14.316	0.007	13.428	0.009
294	131.12082	-48.17047	G2	13.893	0.006	13.239	0.006	12.394	0.007	11.917	0.006	11.488	0.01
295	131.1272	-48.2551	M0	I	I	17.817	0.008	16.232	0.012	15.208	0.01	14.072	0.012

 $^{a}$ All spectral types in this table are estimated from photometry (see text for details)

Note. — 2MASS celestial coordinates are used except for ID 110 where IRAC coordinates are used.

Table 4. Infrared Photometry of Cluster Members

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(err) (mag)		I	I	I	I		Ι	I	I	I	I	0.048	I	I	0.066		I	I	0.047	I	T	I	I	I	L	I	- 0	F 70.0	I	0.047	T	I	I		I	Ι	T	0.057	I	I	I	0.018			I
[24] (mag)		I	I	I	I		I	I	I	I	I	10.753	I	I	10 706		Ι	I	10.713	I	I	I	I	I	I	I	- 0	0110	I	10.503	I	I	I		Ι	Ι	I	10.666	I	I	I	9.317	1		I
(err) (mag)	0.067	0.062	0.136	0.075	0.136	0.044	0.058	0.101	0.013	0.189	0.054	0.016	0.142	0.064	0.016	0.104	0.116	0.033	0.046	0.084	0.116	0.039	0.105	0.068	0.033	0.033	0.057	0.126		0.022	0.07	0.105	0.09	0.036	0.067	0.067	0.116	0.022	0.086	0.07	0.032	0.006	0.101	0.165	0.114
[8.0] (mag)	12.935	13.085	13.645	13.04	13.91	12.366	13.011	13.726	10.618	13.764	12.633	11.181	13.843	13.116	470.01	13.95	13.387	12.022	12.129	13.348	13.564	10.865	13.591	12.694	10.992	12.176	12.341	13 548		11.359	12.919	13.079	13.047	13.020	13.025	13.115	13.521	10.892	13.2	13.036	11.795	9.772	12.377	13.956	13.582
(err) (mag)	0.046	0.064	0.077	0.055	0.083	0.03	0.049	0.065	0.009	0.164	0.033	0.013	0.087	0.042	4000 1100	110.0	0.071	0.029	0.028	0.061	0.102	0.067	0.059	0.048	0.014	0.026	0.052	0.075		0.022	0.042	0.081	0.064	0.02	0.042	0.039	0.086	0.016	0.057	0.049	0.02	0.006	0.058	0.069	0.077
[5.8] (mag)	12.99	13.338	13.447	13.107	13.792	12.389	13.163	13.554	10.588	14.128	12.506	11.215	13.534	12.996	10.059	14.177	13.256	12.12	12.204	13.399	13.839	10.914	13.574	12.82	11.085	12.145	12.280	13 397		11.604	12.986	12.957	12.911	13.81	13.027	13.146	13.583	10.789	13.182	12.994	11.861	9.732	12.528	13.852	13.614
(err) (mag)	0.011	0.022	0.016	0.013	0.02	0.008	0.014	0.014	0.004	0.055	0.01	0.004	0.033	0.013	610.0	0.023	0.015	0.008	0.009	0.013	0.022	0.02	0.017	0.011	0.005	0.008	0.010	0.019		0.006	0.013	0.013	0.015	2 TU.U	0.013	0.011	0.015	0.005	0.022	0.012	0.006	0.003	710.0	0.019	0.017
([4.5] (mag)	13.014	13.254	13.59	13.254	13.889	12.425	13.167	13.609	10.721	14.068	12.606	11.203	13.557	13.264	70.01	14.21	13.367	12.223	12.334	13.454	13.931	11.035	13.677	12.85	11.075	12.287	102.21	13 438		11.663	12.963	12.805	13.057	12.015	13.096	13.139	13.426	10.869	13.37	13.107	11.957	9.731	010.21 13.478	13.93	13.771
(err) (mag)	0.007	0.021	0.013	0.01	0.012	610.0	0.009	0.012	0.003	0.083	0.007	0.004	0.024	0.008	10.0	0.016	0.012	0.006	0.006	0.01	0.014	0.021	0.012	0.009	0.006	0.006	0.015	0.019		0.005	0.009	0.014	0.011	0.005	0.01	0.009	0.013	0.004	0.015	0.008	0.005	0.003	0.009	0.012	0.012
[3.6] (mag)	12.892	13.262	13.57	13.176	13.899	12.395	13.274	13.628	10.774	14.088	12.615	11.412	13.639	13.104	990 OF	14.32	13.464	12.242	12.326	13.471	13.971	10.983	13.721	12.901	11.072	12.243	12.381	13 474		11.694	13	12.992	13.025	12.066	13.051	13.233	13.514	10.89	13.265	13.041	11.883	9.915	12.588	13.925	13.829
(err) (mag)	0.034	0.044	0.058	0.043	0.064	0.029	0.035	0.047	0.023	0.066	0.03	0.021	0.049	0.037	140.0	0.084	0.05	0.026	0.026	0.047	0.062	0.019	0.059	0.035	0.023	0.03	0.00	0.058	0.092	0.024	0.03	0.044	0.036	0.029	0.038	0.044	0.048	0.027	0.086	0.045	0.024	0.019	0.041	0.064	0.066
$K_S{}^a$	12.967	13.36	13.864	13.42	14.106	12.282	13.392	13.792	10.661	14.123	12.853	11.221	13.733	13.329	120.01	14.465	13.744	12.328	12.478	13.669	14.111	10.989	13.991	13.198	11.065	12.324	12.483	13 767	14.412	11.742	13.269	13.015	13.298	12.101	13.188	13.356	13.815	10.867	13.543	13.367	11.948	9.723	12.607	14.119	14.085
(err) (mag)	0.035	0.025	0.036	0.031	0.046	0.022	0.038	0.039	0.023	0.039	0.027	0.023	0.045	0.036	0.04	0.06	0.058	0.025	0.022	0.027	0.052	I	0.055	0.025	0.023	0.031	0.030	0.06	0.065	0.025	0.038	0.038	0.027	0.025	0.032	0.022	0.044	0.029	0.148	0.057	0.026	0.024	0.032	0.058	0.052
H <sup>a</sup> (mag)	13.132	13.671	14.049	13.68	14.281	12.439	13.679	14.017	10.686	14.555	12.991	11.32	14.064	13.588	707.CT	14.725	13.949	12.46	12.714	13.926	14.422	I	14.214	13.388	11.171	12.511	15.090 15.055	13 897	14.787	11.808	13.494	13.278	13.406	12.224	13.357	13.481	13.973	10.938	13.8	13.782	12.142	9.767	12.8/1	14.363	14.285
(err) (mag)	0.029	0.032	0.032	0.029	0.043	0.02	0.03	0.026	0.023	0.037	0.022	0.022	0.041	0.032	100.0	0.047	0.044	0.022	0.023	0.03	0.049	I	0.046	0.026	0.023	0.024	0.036	0.045	0.058	0.023	0.029	0.026	0.024	0.030	0.027	0.024	0.036	0.023	0.074	0.05	0.024	0.022	0.042	0.042	0.044
J <sup>a</sup> (mag)	13.8	14.339	14.735	14.374	15.066	14.4/ 12.954	14.326	14.72	10.805	15.123	13.762	11.645	14.846	14.269	11 400	15.449	14.664	13.094	13.365	14.599	15.161	I	14.921	14.101	11.28	13.076	15.413	14 604	15.348	11.973	14.199	13.978	14.118	12.826	13.902	14.286	14.668	10.961	14.519	14.39	12.827	9.734	13.014	14.001 15.134	15.078
D	51	52	53	54	55	57 27	58	59	60	61	62	63	64	65 65	00	- 89 89	69	70	71	72	73	74	75	76	77	78	6/	20 <b>2</b>	82	83	84	85	9 0 8 0 8 0	~ ~ ~	89	06	91	92	93	$^{94}$	95	96	97	06 66	100

Table 4—Continued

D.		1																																													
	(err) (mag)	0.036	I	I		I	I	I	0.031	Ţ	I	I	I	0.025	I	0.021	I	I	I	I	I	1	0.033		0.059	I	I				I	I	I	I	I	I	0.057	0.031	I	0.034		0.022	0.005	0700	I	0.01	$^{-}_{0.022}$
	[24] (mag)	10.304	I	I		I	Ι	I	10.32	I	I	I	I	9.964	I	9.646	I	I	I	I	I		10.122		10.877	I	I			- 1	I	I	I	I	I	I	10.57	10.088	I	10.269		9.702	2 203	1 000	I	8.292	- 9.63
	(err) (mag)	0.017	0.012	0.128	0.155	0.05	0.108	0.08	0.084	0.065	0.1	0.074	0.043	0.06	0.121	0.073	0.137	0.113	0.214	0.099	0.017	0.108	0.097	0.147	0.014	0.100	201.0	140.0	0.031	0.204	0.069	0.071	0.318	0.048	0.117	I	0.023	0.059	0.294	0.02	0.036	0.012	0.004	0.042	0.055	0.011	0.044 0.039
	[8.0] (mag)	11.01	10.846	13.64	13.818	12.581	13.874	12.908	13.217	12.758	12.798	12.521	12.473	12.997	13.922	12.93	13.158	13.259	13.93	13.02	11.541	13.18	12.944	13.203	10.442	0/0.01	000.61 1 004	12 740	11 567	14.265	13.013	12.454	13.376	12.589	13.401	I	11.335	12.514	14.156	10.603	11.65	10.641	10.044 0.031	11 688	12.205	10.314	12.444 11.142
	(err) (mag)	0.011	0.012	0.09	0.158	0.031	0.117	0.05	0.102	0.041	0.043	0.097	0.034	0.061	0.108	0.087	0.05	0.048	0.077	0.046	0.015	0.062	0.061	0.082	0.009	ent.u	100.0	1120.0	111.0	0.12	0.045	0.03	0.098	0.047	0.065	I	0.014	0.041	0.103	0.011	0.022	0.01	00.00	0.004	0.027	0.009	0.029 0.012
	[5.8] (mag)	11.028	10.871	13.8	13.172	12.571	14.231	13.075	14.051	12.799	12.782	12.503	12.715	13.507	14.049	13.708	13.085	13.216	13.8	13.075	11.508	13.3	13.403	13.376	10.48	CD0.CT	- 11 000	106.11	11 562	14.32	12.985	12.337	13.603	12.824	13.218	I	11.264	12.894	13.848	10.556	11.743	10.759	14.61 0.079	11 591	12.157	10.413	12.382 11.125
	(err) (mag)	0.004	0.004	0.02	0.019	0.009	0.021	0.013	0.024	0.011	0.01	0.017	0.009	0.015	0.018	0.023	0.015	0.015	0.018	0.013	0.005	0.02	0.017	0.018	0.004	610.0	1000	0.010	0.005	0.022	0.012	0.009	0.017	0.009	0.016	I	0.005	0.012	0.021	0.005	0.006	0.005	610.0	0.006	0.008	0.004	0.008 0.005
	([4.5] (mag)	11.073	10.934	14.02	13.873	12.621	14.176	13.222	14.167	12.823	12.973	12.495	12.7	13.602	14.119	13.954	13.248	13.264	13.97	13.148	11.484	13.2	13.805	13.274	10.542	14.001	1 6 5	12 756	11 655	14.158	13.023	12.443	13.732	12.819	13.358	I	11.334	13.211	13.988	10.65	11.752	10.807	10.404 0.019	3.012 11 626	12.168	10.545	12.518 11.148
	(err) (mag)	0.004	0.003	0.015	0.016	0.008	0.017	0.009	0.018	0.01	0.009	0.015	0.007	0.011	0.016	0.018	0.01	0.012	0.016	0.009	0.005	0.016	0.014	0.019	0.004	otn-n	1000	0.000	010.0	0.014	0.009	0.009	0.012	0.007	0.012	I	0.005	0.01	0.016	0.006	0.006	0.004	610.0	0.005	0.007	0.004	0.006 0.004
	[3.6] (mag)	11.077	10.934	14.06	13.946	12.733	14.155	13.29	14.43	12.833	13.015	12.588	12.707	13.661	14.254	14.139	13.261	13.341	14.062	13.045	11.509	13.373	14.027	13.276	10.566	14.344	10.070	12 000	11 578	14.128	13.151	12.485	13.58	12.823	13.311	I	11.319	13.431	14.123	10.605	11.756	10.752	0.083 0.083	3.003 11 645	12.241	10.471	12.513 11.165
	(err) (mag)	0.019	0.019	0.07	0.068	0.031	0.099	0.044	0.106	0.031	0.04	0.019	0.047	0.096	0.094	0.1	0.057	0.04	0.078	0.039	0.029	0.052	0.086	0.044	0.021	0.03	21.0	120.0	200.0	610.0	0.041	0.033	0.052	0.023	0.049	0.094	0.021	0.06	0.07	0.023	0.024	0.025	0.001	0.021	0.024	0.019	0.027 0.021
a 	$K_S^a$ (mag)	11.074	11.037	14.202	14.155	12.873	14.554	13.416	14.689	13.107	13.031	12.692	12.727	14.191	14.388	14.557	13.428	13.431	14.263	13.31	11.539	13.468	14.438	13.49	10.492	100.41	110.011	14.045	11 617	14.41	13.404	12.693	13.791	12.865	13.572	14.384	11.209	13.875	14.363	10.611	11.775	10.742	200.61 8 063	11 601	12.297	10.368	12.609 11.132
	(err) (mag)	0.022	0.024	0.051	0.063	0.022	0.058	0.04	0.079	0.021	0.035	0.022	0.065	0.046	0.076		0.073	0.032	0.067	0.036	0.034	0.057	0.062	0.043	0.022	0.014	0.004	0.040	0.043	0.06	0.049	0.035	0.053	0.022	0.042	0.085	0.024	0.049	0.063	0.024	0.027	0.022	0.033	0.022	0.026	0.024	0.022 0.021
	$H^{a}$ (mag)	11.216	11.21	14.459	14.58	13.104	14.729	13.639	14.869	13.364	13.217	12.856	12.952	14.202	14.72	1	13.722	13.583	14.639	13.471	11.617	13.692	14.751	13.696	10.632	14.040	14.019	2011.21	14.327 11 797	14.743	13.687	13.019	14.07	13.158	13.773	14.465	11.278	14.242	14.627	10.675	11.916	10.766	200.01 8 038	11 696	12.441	10.406	12.779 11.159
	(err) (mag)	0.027	0.021	0.045	0.034	0.028	0.039	0.03	0.057	0.022	0.034	0.022	0.06	0.041	0.044	1	0.034	0.032	0.048	0.03	0.026	0.049	0.045	0.039	0.024	100.0	- 000	0.046	0.040	0.044	0.039	0.032	0.033	0.026	0.029	0.081	0.027	0.037	0.044	0.026	0.024	0.026	0.04 0.021	0.026	0.03	0.026	0.026 0.024
, ,	Jء (mag)	11.686	11.821	15.157	14.300	13.824	15.365	14.482	15.68	14.052	14.006	13.514	13.694	14.898	15.331		14.477	14.42	15.287	14.237	11.685	14.511	15.351	14.422	11.192	001.01	- 10 01	15 162	220 II	15.354	14.313	13.762	14.874	13.87	14.493	15.182	11.387	15.083	15.345	10.89	12.388	10.743	14.00/ 8 886	12.218	13.126	10.469	13.53 11.224
	ID	151	152	153	155	156	157	158	159	160	161	162	163	164	165	166	167	168 1	169	170	171	172	173	174	175	1770	171	170	180	181	182	183	184	185	186	187	188	189	190	191	192	193	105 105	196	197	198	$199 \\ 200$

Table 4—Continued

	(err)	на	(err)	$K_S{}^a$	(err)	[3.6]	(err)	([4.5]	(err)	[5.8]	(err)	[8.0]	(err)	[24]	(err)
(mag)		(mag)	(mag)	(mag)	(mag)	(mag)	(mag)	(mag)	(mag)	(mag)	(mag)	(mag)	(mag)	(mag)	(mag)
0.026		13.001	0.022	12.817	0.029	12.662	0.007	12.661	0.009	12.503	0.033	12.448	0.094	I	I
0.035		14.239	0.032	14.005	0.05	13.727	0.011	13.667	0.015	13.54	0.068	13.426	0.08	I	I
0.033		13.593	0.032	13.49	0.047	12.621	0.016	13.289	0.015	13,158	0.055	12.892	0.095		
0.037		14.085	0.047	13.829	0.049	13.668	0.011	13.611	0.015	13.487	0.07	13.308	0.095	I	I
0.057		13.958	0.085	13.673	0.051	13.555	0.011	13.502	0.014	13.582	0.086	13.33	0.117	I	I
0.032		10.373	0.022	10.296	0.021	10.297	0.003	10.316	0.003	10.292	0.008	10.231	0.009	10.159	0.029
0.040		14.303 11 003	0.00 1000	14.341 11.070	0.012 0.023	11 007	0.004	11.021	0.01	11.052	0.099	13.821	0.130	1	1 1
0.022		12.15	0.021	11.993	0.019	11.861	0.005	11.843	0.004	11.847	0.019	11.748	0.03		
0.04		14.231	0.044	14.054	0.062	13.723	0.012	13.656	0.015	13.641	0.073	13.472	0.093	I	I
0.02	6	11.25	0.029	11.139	0.027	11.247	0.004	11.282	0.005	11.072	0.014	11.038	0.016	I	I
0.03	ۍ.	13.689	0.042	13.207	0.039	12.722	0.008	12.339	0.008	12.049	0.024	11.208	0.026	8.309	0.01
0.03	ມດາ	13.708	0.034	13.426	0.041	13.32	0.011	13.302	0.013	13.159	0.059	13.082	0.172	1 0	0
0.07	ດເ	12.865	0.062	12.626	0.04	12.473	710.0	116.21	0.016 0.00	12.454	0.049	10.899	0.045	10.0	0.008
0.04	e e	14.486 12 036	0.065	14.411 12.75	0.079	14.075 13 460	0.013	13.927	0.02	14.045	0.126	13.789	0.304		
0.0	2 4	12.429	0.021	12.224	0.026	12.359	0.006	12.101	010.0	12.07	0.025	12.077	0.051		
0.03	6	13.955	0.049	13.739	0.051	13.368	0.01	13.264	0.013	13.082	0.054	12.482	0.079	10.255	0.035
0.02	ŝ	11.328	0.022	11.292	0.023	11.219	0.004	11.27	0.005	11.263	0.019	11.234	0.054	I	I
0.03	2	9.327	0.038	9.353	0.024	9.45	0.004	9.467	0.003	9.504	0.005	9.413	0.018	9.65	0.026
0.0	24	9.754	0.022	9.759	0.021	9.871	0.003	9.876	0.003	9.781	0.006	9.879	0.017	I	I
0.0	39	13.345	0.044	13.147	0.039	13.002	0.009	12.944	0.011	12.803	0.063	12.593	0.076	I	I
0.0	30	14.096 12 507	0.045	13.848 12 244	0.028	13.751 12 064	0.000	12.743	0.019	13.824	0.085	14.061	0.173	1	1
0.0	50	13.058	0.022	12.855	0.037	12.598	0.007	12.629	0.01	12.582	0.043	12.652	0.13	I	I
0.0	35	13.24	0.03	13.02	0.04	12.969	0.008	12.846	0.01	12.726	0.045	13.119	0.133	I	I
0.0	19	8.491	0.036	8.458	0.021	8.538	0.002	8.542	0.002	8.523	0.004	8.507	0.003	8.495	0.014
0.0	32	13.596	0.037	13.376	0.038	13.177	0.011	13.163	0.012	13.125	0.066	13.558	0.138		
0.0	56	13.719	0.043	13.459	0.04	13.161	0.01	12.907	0.01	12.568	0.045	12.001	0.095	9.328	0.02
	# °	19 A60	0.033	10.070	700.0	10 445	9000	10.000	200 0	10.057	2000	10.01	0.065		
000	2 8	13.115	0.022	12.836	0.031	12.622	0.007	12.702	0.009	12.59	0.043	12.577	0.127		
0.0	43	14.204	0.053	13.92	0.064	13.744	0.011	13.86	0.019	13.703	0.071	13.691	0.11	I	I
0.0	32	13.843	0.037	13.618	0.045	13.495	0.013	13.452	0.015	13.665	0.091	14.243	0.511	I	I
0.0 0	16	13.714	0.053	13.522	0.083	13.213	0.009	13.089	0.016	13.128	0.083	13.28	0.192	I	I
	13	14.307 14-386	0.040	14.17 14.108	00.0	14.1 13 867	0.014	13 778	0.018	13.665	0.088	13 714	0.41 0.41		
0.0	4	14.242	0.045	13.98	0.069	13.796	0.013	13.701	0.015	13.848	0.083	13.501	0.087	I	I
0.0	23	13.532	0.035	13.169	0.041	12.624	0.011	12.319	0.009	11.926	0.023	11.283	0.036	8.859	0.014
0.0	e	13.733	0.037	13.466	0.045	13.42	0.01	13.307	0.013	13.233	0.058	13.372	0.096	Ι	Ι
0.0	23	10.174	0.022	10.139	0.019	10.144	0.003	10.218	0.004	10.19	0.008	10.191	0.015	9.852	0.024
0.0	22	14.082	0.037	13.771	0.058	13.617	0.011	13.532	0.015	13.604	0.082	13.608	0.205	I	I
0.0	2 6	13.103 14 179	0.027	12.966 12.966	0.038	12.863	0.018	12.808	10.01	12.743	0.038	12.793 12.406	0.069	- 10	- 0.00
	1 6	13.534	0.022	13.297	0.033	13.082	0.009	13.05	0.012	12.962	0.044	13.093	0.138	0.14 k	770.0
0.0	200	13.932	0.054	13.659	0.043	13.46	0.011	13.463	0.017	13.31	0.061	12.95	0.104	I	I
0.0	53	14.26	0.082	14.006	0.072	13.756	0.019	13.786	0.019	13.671	0.138	13.631	0.371	I	I
0.02	63	14.088	0.021	13.818	0.058	13.672	0.011	13.561	0.015	13.479	0.063	13.305	0.12	I	I
0.0	43	14.501	0.056	14.303	0.073	13.988	0.016	13.994	0.022	14.073	0.093	13.746	0.154	I	I

Table 4—Continued

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le 4—
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(err) (mag)	Ι	I	0.023	I	0	0.047	0.068	I	I	I	I	I	0.03	I	I	I	I	I	I	I	I	I	I	I	0.027	I	0.027	Ţ	I	Ţ	0.019	I	0.019	I	0.069	I	0.054	I	Ţ	I	Ţ	I	I	0.058	I
[24] (mag)	Ι	I	9.498	I	•	9.498	10.964	I	I	I	I	I	10.163	I	I	I	Ι	I	Ι	I	Ι	I	I	I	10.029	I	10.04	I	I	I	9.637	I	9.515	I	11.094	I	10.747	I	I	I	I	I	I	10.745	I
(err) (mag)	0.027	0.062	0.021	0.141	0.048	0.05	0.095	0.181	0.076	0.206	0.127	I	0.008	0.076	0.135	0.202	0.162	0.018	0.116	0.936	0.041	0.042	0.09	0.044	0.007	0.038	0.011	0.061	0.162	0.065	0.027	0.128	0.019	0.056	0.012	0.105	0.018	0.026	0.019	0.022	0.149	0.022	0.03	0.015	0.027
[8.0] (mag)	11.937	12.998	10.246	12.462	12.24	12.616	13.012	13.77	12.93	13.55	13.001	I	10.132	13.151	13.759	14.261	13.41	11.259	13.534	14.617	11.998	12.433	13.216	12.041	10.041	11.652	10.425	12.573	13.885	12.827	11.857	13.42	11.426	13.132	10.897	13.592	10.987	11.453	11.248	11.209	13.91	11.184	11.645	10.643	12.048
(err) (mag)	Ι	0.065	0.009	0.047	0.023	0.069	0.07	0.138	0.051	0.073	0.062	I	0.008	0.044	0.071	0.103	0.062	0.016	0.072	0.105	0.021	0.036	0.064	0.026	0.008	0.018	0.009	0.035	0.103	0.04	0.021	0.064	0.016	0.042	0.011	0.054	0.011	0.016	0.014	0.013	0.072	0.013	0.017	0.011	0.022
[5.8] (mag)	I	13.482	10.347	12.769	12.172	13.391	13.382	14.195	13.169	13.346	13.057	I	10.19	13.099	13.535	14.206	13.207	11.247	13.77	13.977	12.085	12.506	13.483	12.095	10.284	11.704	10.425	12.548	14.093	12.941	11.894	13.387	11.529	13.083	10.95	13.407	11.028	11.378	11.36	11.238	13.97	11.125	11.687	10.713	12.027
(err) (mag)	0.013	0.023	0.004	0.011	0.007	0.016	0.02	0.019	0.011	0.014	0.015	0.007	0.003	0.013	0.014	0.022	0.016	0.005	0.015	0.023	0.007	0.008	0.015	0.007	0.003	0.007	0.004	0.011	0.034	0.012	0.006	0.012	0.005	0.013	0.005	0.015	0.004	0.006	0.005	0.005	0.022	0.005	0.007	0.005	0.006
([4.5] (mag)	12.561	13.525	10.414	12.794	12.258	13.593	13.663	13.98	13.159	13.423	13.137	11.862	10.135	13.3	13.655	14.204	13.309	11.338	13.579	14.178	12.156	12.475	13.391	12.114	10.193	11.904	10.433	12.647	14.258	13.078	11.933	13.368	11.508	13.329	11.341	13.665	11.026	11.463	11.196	11.31	14.024	11.236	11.72	10.76	12.083
(err) (mag)	0.01	0.017	0.003	0.01	0.005	0.012	0.017	0.017	0.009	0.011	0.011	0.008	0.003	0.009	0.011	0.017	0.011	0.004	0.012	0.019	0.006	0.008	0.011	0.006	0.002	0.004	0.003	0.009	0.027	0.009	0.005	0.01	0.005	0.009	0.004	0.012	0.004	0.005	0.004	0.004	0.016	0.004	0.006	0.004	0.005
[3.6] (mag)	12.516	13.687	10.376	12.939	12.191	13.824	14.047	14.102	13.272	13.458	13.249	12.018	10.188	13.21	13.683	14.243	13.235	11.313	13.802	14.203	12.238	12.549	13.365	12.069	10.16	11.753	10.487	12.65	14.267	13.104	12.075	13.436	11.66	13.311	10.986	13.762	11.048	11.532	11.251	11.275	14.042	11.237	11.745	10.671	12.134
(err) (mag)	0.051	0.063	0.019	0.039	0.024	0.071	0.102	0.096	0.043	0.061	0.053	0.036	0.026	0.041	0.059	0.089	0.047	0.021	0.064	0.106	0.019	0.026	0.044	0.033	0.019	0.023	0.021	0.045	0.097	0.041	0.023	0.039	0.023	0.035	0.021	0.069	0.021	0.029	0.023	0.019	0.086	0.019	0.027	0.03	0.024
${\rm K}_{S}{}^{\rm a}$ (mag)	13.014	13.999	10.408	13.265	12.238	14.065	14.691	14.577	13.37	13.661	13.43	11.987	10.109	13.402	13.984	14.48	13.47	11.356	13.905	14.649	12.15	12.483	13.524	12.154	10.159	11.842	10.532	12.84	14.611	13.261	12.004	13.606	11.49	13.334	11.005	14.175	11.013	11.445	11.245	11.365	14.348	11.264	11.851	10.697	12.3
(err) (mag)	I	0.063	0.026	0.026	0.024	0.07	0.085	0.059	0.029	0.032	0.04	0.049	0.031	0.041	0.044	0.072	0.046	0.022	0.043	0.073	0.022	0.022	0.045	0.039	0.025	0.025	0.025	0.031	0.078	0.031	0.023	0.027	0.022	0.033	0.023	0.056	0.023	0.027	0.022	0.022	0.067	0.021	0.025	0.039	0.027
H <sup>a</sup> (mag)	Ι	14.379	10.503	13.513	12.357	14.351	14.905	14.647	13.706	13.799	13.542	12.12	10.142	13.646	14.192	14.789	13.619	11.349	14.162	14.859	12.261	12.602	13.779	12.293	10.251	12.021	10.576	13.149	14.85	13.502	12.147	13.752	11.59	13.66	11.174	14.387	11.085	11.56	11.349	11.557	14.575	11.328	12.023	10.771	12.528
(err) (mag)	I	0.037	0.024	0.028	0.022	0.044	0.059	0.059	0.024	0.023	0.041	0.049	0.03	0.034	0.04	0.051	0.028	0.024	0.04	0.054	0.024	0.024	0.037	0.036	0.023	0.026	0.023	0.048	0.059	0.026	0.026	0.032	0.026	0.024	0.024	0.034	0.022	0.028	0.024	0.024	0.05	0.023	0.024	0.03	0.024
J <sup>a</sup> (mag)	Ι	14.914	10.726	14.059	12.724	14.991	15.567	15.351	14.346	14.548	14.231	12.564	10.163	14.361	14.923	15.422	14.356	11.825	14.822	15.446	12.761	13.254	14.488	12.935	10.424	12.671	10.623	13.715	15.436	14.118	12.744	14.569	11.79	14.345	11.8	15.025	11.105	11.855	11.589	12.194	15.263	11.637	12.672	11.135	13.13
D	251	252	253	254	255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295

<sup>a</sup> JHK photometry from 2MASS

ID	$_{\rm SpT}$	[3.6]-[5.8] (mag)	$^{\rm err}$ (mag)	[4.5]-[8] (mag)	$^{\rm err}$ (mag)	$\begin{array}{c} [8]-[24] \\ (mag) \end{array}$	$^{\rm err}$ (mag)	Disk Type
14	-	-0.014	0.005	0.162	0.006	1.154	0.034	D?
25	M6	0.467	0.050	0.756	0.055	2.795	0.057	II
29	M6	0.36	0.062	0.81	0.070	3.873	0.069	Т
36	F9	0.103	0.022	0.142	0.028	1.685	0.036	D?
41	F5	0.137	0.016	0.199	0.020	0.829	0.042	D
44	-	0.096	0.040	0.099	0.058	1.694	0.092	WT
63	$G_{2}$	0.197	0.014	0.022	0.016	0.428	0.051	D
71	_	0.122	0.029	0.205	0.047	1.416	0.066	D?
80	-	0.702	0.060	0.9	0.060	3.156	0.062	II
83	F6	0.09	0.023	0.304	0.023	0.856	0.052	D
96	B9/A0V	0.183	0.007	-0.041	0.007	0.455	0.019	D
102	M6	0.459	0.041	0.711	0.046	2.127	0.059	II
107	B9V	0.026	0.008	0.052	0.009	0.902	0.031	D
109	-	0.598	0.080	1.014	0.062	3.211	0.062	II
110	_	0.798	0.084	0.986	0.070	2.648	0.079	II
122	F7	0.14	0.018	0.037	0.033	0.871	0.064	D
124	F3	0.051	0.015	0.062	0.022	2.447	0.025	D
130	_	0.618	0.027	0.888	0.037	2.63	0.039	II
133	_	0.34	0.127	1.088	0.088	3.167	0.086	т
138	B9	0.438	0.010	0.881	0.008	3.026	0.010	П
140	_	0.592	0.053	0.862	0.056	2.648	0.060	II
142	A5	0.053	0.012	0.178	0.012	2.374	0.014	D
147	_	0.551	0.074	1.044	0.087	2.983	0.089	T
148	B9V	0.068	0.009	0.036	0.011	0.281	0.029	D
151		0.049	0.012	0.063	0.017	0.706	0.040	D?
159	_	0.379	0.104	0.95	0.087	2 897	0.090	т.
164	M6	0.154	0.062	0.605	0.062	3 033	0.065	Ť
166	_	0 431	0.089	1 024	0.077	3 284	0.076	П.
173	_	0.624	0.063	0.861	0.098	2.822	0.102	II
188	A4	0.055	0.015	-0.001	0.024	0.765	0.061	D
189	_	0.537	0.042	0.697	0.060	2 426	0.067	л П
191	F1	0.049	0.013	0.047	0.021	0.334	0.039	D
193	B8	-0.007	0.011	0.166	0.013	0.939	0.025	D
195	B3IV-V	0.011	0.004	-0.019	0.005	0.228	0.025	D?
198	B8	0.058	0.010	0.231	0.012	2.022	0.015	р.
200	AO	0.04	0.013	0.006	0.039	1.512	0.045	D
213	-	0.673	0.025	1 1 3 1	0.005	2 800	0.028	п
215	_	0.019	0.052	0.612	0.048	5 289	0.046	т
210	M6	0.286	0.055	0.782	0.040	2 200	0.040	WT
230	M6	0.593	0.035	0.906	0.000	2.227	0.000	II II
240	-	0.535	0.040	1.036	0.037	2.073	0.039	11
240	B7V	-0.046	0.025	0.027	0.037	0 330	0.039	D
245		0.492	0.003	0.73	0.010	2 664	0.028	п
253	F4	0.432	0.040	0.168	0.043	0.748	0.031	D
256	1°4 M6	0.029	0.009	0.108	0.021	3 119	0.031	U U
250	1110	0.433	0.070	0.511	0.052	2.049	0.009	11
201		0.003	0.072	0.001	0.097	0.385	0.117	D
411	A1	0.002	0.009	0.008	0.012	0.363	0.029	
281	K /	11 1 8 1	11 11.7.7	11 11 / 16	111122		111132	VA/ · · ·

Table 5. Disk Candidates in IC 2395

Table 6. Proportion of Transitional Disk Candidates Among Known Members of Clusters and Associations

12 - Luhman (2004) finds the age to be similar to that of n Cha, which is estimated at 11 Myr by Bell et al. (2015), 13 - Jeffries et al. (2014); Hernández et al. (2008) also show this association to be similar in age to NGC 2362 and Orion OB1b, 14 - the lack of stars earlier than B1 (E. E. Mamajek, private communication) indicates ~ 15 Myr, and the placement of the sub-association 25 Ori on the HR diagram showing it to be significantly older than Ori OB1b (Briceño et al. 2007) - see also Wolk (1996), 15 - Sicilia-Aguilar et al. (2008), 20 - Sivilia-Aguilar et al. (2003), 21 - Wilking et al. (2003), 17 - Flaherty & Muzerolle (2003), 18 - Park & Sung (2002), 19 - Winston et al. (2009), 20 - Barrado y Navascués & Martin (2003), 21 - Luhman et al. (2003), 22 - Guermuth et al. (2003), 23 - Luhman et al. (2003), 24 - Hernández et al. (2003), 25 - Unhan et al. (2003), 26 - Barrado y Navascués & Martin (2003), 27 - Briceño et al. (2007), 28 - Carpenter et al. (2006), 29 - Murphy et al. (2003), 27 - Briceño et al. (2007), 28 - Carpenter et al. (2006), 29 - Murphy et al. (2013), 30 - Luhman et al. (2003), 26 - Barrado y Navascués & Martin (2003), 27 - Briceño et al. (2007), 28 - Carpenter et al. (2006), 29 - Murphy et al. (2013), 30 - Luhman et al. (2008), 28 - Murphy et al. (2013), 20 - Luhman et al. (2003), 28 - Carpenter et al. (2006), 29 - Murphy et al. (2013), 30 - Luhman et al. (2003), 26 - Barrado y Navascués & Martin (2003), 27 - Briceño et al. (2007), 28 - Carpenter et al. (2006), 29 - Murphy et al. (2013), 30 - Luhman et al. (2003), 20 - Barrado y Navascués & Martin (2003), 27 - Briceño et al. (2007), 28 - Carpenter et al. (2006), 29 - Murphy et al. (2013), 30 - Luhman et al. (2003), 20 - Barrado y Navascués & Martin (2003), 27 - Briceño et al. (2007), 28 - Carpenter et al. (2006), 29 - Murphy et al. (2013), 30 - Luhman et al. (2003), 20 - Barrado y Navascués & Martin (2003), 27 - Briceño et al. (2007), 28 - Carpenter et al. (2006), 29 - Murphy et al. (2013), 30 - Luhman et al. (2003), 20 - Barrado y Navasc al. (2013), 41 - Luhman et al. (2003, 2005); Stelzer et al. (2012), 42 - Schneider et al. (2012); Murphy et al. (2015), 43 - Luhman & Mamajek (2012); Rizzuto et al. (2015), 44 - Megeath et al. (2005) and Gautier et al. (2008), 45 - (Currie et al. 2009), 46 - Pecaut et al. (2012); Song et al. (2012)) Column (5) Number of transition disks over total of  $24 \ \mu$  bright disks; Column (6) Percentage of transitional disks with nominal errors; Columns (7 - 10): Same for increasing excess thresholds; Column (11): Reference(s) for photometry (47 - Evans et al. (2009), 48 - (Balog et al. 2007), 49 - Harvey et al. (2007), 50 - Getman et al. (2002); Winston et al. (2009), 51 - WISE, 52 - Luhman & Mamajek (2012) plus WISE, ) Column (1): Cluster designation; Column (2): Adopted age; Column (3): Reference(s) for age (1 - Brickson et al. (2011) and Takagi et al. (2015), 2 - Bell et al. (2013), 3 - Brickson et al. (2015) find an age similar to that of  $\rho$  Oph, with both estimates using the same technique, 4 - Rees et al. (2016), 5 - Luhman et al. (2016) show age is similar to or younger than that al. (2015) find an age similar to that of  $\rho$  Oph, with both estimates using the same technique, 4 - Rees et al. (2016), 5 - Luhman et al. (2016) show age is similar to or younger than that al. (2015) find an age similar to that of  $\rho$  Oph, with both estimates using the same technique, 4 - Rees et al. (2016), 5 - Luhman et al. (2016) show age is similar to a vounger that al. (2013), 7 of IC 348, which has an age from Bell et al. (2013), 6 - Luhman et al. (2008) and discussion therein shows the age is similar to that of IC 348, which has an age from Bell et al. (2013), 7 Giardino et al. (2007); Winston et al. (2009); Brickson et al. (2015), 38 - Luhman et al. (2010), 39 - Getman et al. (2002); Winston et al. (2009), 40 - Luhman (2007); López Martí et al. (2013), 41 - Luhman et al. (2003, 2005); Stelzer et al. (2012), 42 - Schneider et al. (2012); Murphy et al. (2015), 43 - Luhman & Mamajek (2012); Rizzuto et al. (2015), 44 this work, 8 - Bell et al. (2015), 9 - Weinberger et al. (2013); the estimate by Herczeg & Hillenbrand (2015) is consistent but slightly younger, 10 - see text, 11 - Pecaut et al. (2012), membership (35 - Gagné et al. (2004); Wilking et al. (2005); Ozawa et al. (2005); Wilking et al. (2008); Barsony et al. (2012), 36 - Chen et al. (2007); Wang et al. (2008), 37 -(2004), 31 - Luhman (2004); Megeath et al. (2005), 32 - Dahm & Hillenbrand (2007), 33 - Hernández et al. (2008), 34 - Mamajek et al. (2002)); Column (4): Reference(s) for



Fig. 1.— IC 2395 three color composite image composed of IRAC wavelengths  $3.6 \,\mu\text{m}$  (blue) and  $8.0 \,\mu\text{m}$  (green) and MIPS  $24 \,\mu\text{m}$  (red). The coordinates are relative to RA = 130.6111, DEC = -48.1690. Likely contributors to the emission in the  $8.0 \,\mu\text{m}$  channel are silicate grains and aromatic molecules, seen as the bright green areas.



Fig. 2.— The central ~  $60' \times 40'$  mosaic of IC 2395 taken with the MIPS 24  $\mu$ m channel. The coordinates are relative to RA = 130.6389, DEC = -48.0688. Sources with disks are identified with symbols: *cyan crosses* represent Class II candidates, *magenta circles* represent transition disk candidates, and *red diamonds* represent debris disk candidates. The point source FWHM is 5.7" and the platescale is 1.25"/pixel.



Fig. 3.— Optical - near-infrared CC diagram of IC 2395 cluster member candidates (green symbols) selected for the spectroscopic survey together with the complete sample of the photometric data (red symbols). Blue symbols show the stars with IR excess that may not be cluster members but were included in the spectroscopic sample.



Fig. 4.— Radial velocity distributions toward IC 2395. The Gaussian fit is centered at 24.7 km/s. The vertical blue lines indicate  $\pm$  one full width at half maximum above and below the center velocity. This velocity range was used to identify cluster members; it corresponds to  $\pm 2.4 \sigma$ .



Fig. 5.— V, V-J CM diagram with semi-empirical (see Bell et al. (2014) for details) model isochrones using the Dartmouth interior models. The red solid isochrone is for 9 Myr; it has been reddened by E(B-V)=0.09 and shifted in distance assuming a modulus of 9.5 The dashed line is the same but shifted 0.75 mag higher i.e. where we would expect the equal mass binaries to lie.



Fig. 6.— Optical - near-infrared CM and CC diagrams of IC 2395 cluster members. Green dots: members without IR excess, red: debris disk candidates, magenta: transitional disk candidates, cyan: class II candidates. Black lines show the 10- and 3Myr isochrones (Palla & Stahler 1999) (traditional age scale) and the ZAMS (Marigo et al. 2008).



Fig. 7.— Dereddened V-K versus  $K_s$ -[24.0] CC diagram. Symbols are as in Figure 6. The black line represent the photospheric colours of main sequence stars (Urban et al. 2012), while the bounding lines are the typical range of uncertainties in projecting the color from shorter wavelengths (including random and systematic errors).



Fig. 8.— Selection criterion for transition disks using IRAC colors. The points show the distribution of the colors for all the objects with [8] - [24] > 1.5 in all the clusters under study (see text), to which we have fitted a Gaussian (solid red line) confined to the upper 2/3 of the points to avoid biasing the fit with the wings of the distribution. The thin green line shows the distribution for the sources with smaller [24] excess emission. The vertical line shows the criterion adopted to identify transitional disk candidates (i.e., [3.6] - [5.8] < 0.4).



Fig. 9.— Color-color diagram illustrating the selection criteria (within the red box) for transitional disks (i.e., [3.6] - [5.8] < 0.4 & [8] - [24] > 1.5) applied to IC 2395. Symbols are as in Figures 6 and 7.



Fig. 10.— Percentage of transitional disks vs. age. defined as No. Transitional/(No. Transitional + No. Class II) \* 100. This graph uses the traditional age scale because it is more complete for the relevant clusters/associations.