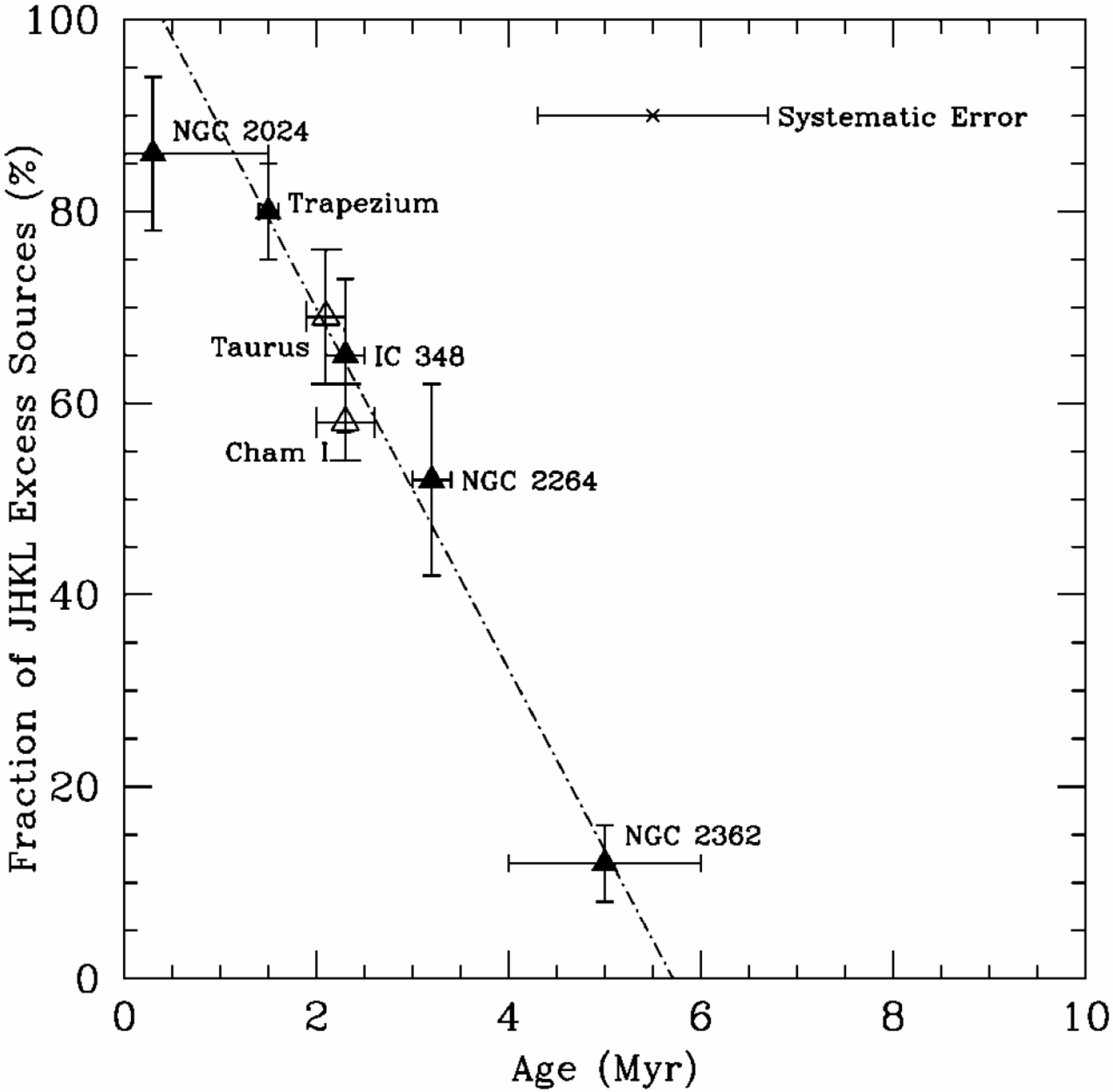
The Astrophysical Journal, 553:L153–L156, 2001 June 1

DISK FREQUENCIES AND LIFETIMES IN YOUNG CLUSTERS

Karl E. Haisch, Jr.[1,2,3,4] and Elizabeth A. Lada[3,5]
Department of Astronomy, University of Florida, 211 Bryant Space Sciences Research Building, Gainesville, FL 32611
and
Charles J. Lada[3]
Smithsonian Astrophysical Observatory, 60 Garden Street, Cambridge, MA 02138
Received 2001 February 21; accepted 2001 April 20; published 2001 May 16

ABSTRACT

We report the results of the first sensitive *L*-band survey of the intermediate-age (2.5–30 Myr) clusters NGC 2264, NGC 2362, and NGC 1960. We use *JHKL* colors to obtain a census of the circumstellar disk fractions in each cluster. We find disk fractions of 52% ± 10%, 12% ± 4%, and 3% ± 3% for the three clusters, respectively. Together with our previously published *JHKL* investigations of the younger NGC 2024, Trapezium, and IC 348 clusters, we have completed the first systematic and homogeneous survey for circumstellar disks in a sample of young clusters that both span a significant range in age (0.3–30 Myr) and contain statistically significant numbers of stars whose masses span nearly the entire stellar mass spectrum. Analysis of the combined survey indicates that the cluster disk fraction is initially very high (≥80%) and rapidly decreases with increasing cluster age, such that one-half the stars within the clusters lose their disks in ≲3 Myr. Moreover, these observations yield an overall disk lifetime of ~6 Myr in the surveyed cluster sample. This is the timescale for essentially all the stars in a cluster to lose their disks. This should set a meaningful constraint for the planet-building timescale in stellar clusters. The implications of these results for current theories of planet formation are briefly discussed.



Fraction of JHKL Excess Sources (%)
Age (Myr)
Systematic Error
NGC 2024
Trapezium
Taurus
IC 348
Cham I
NGC 2264
NGC 2362
0
20
40
60
80
100
0
2
4
6
8
10

Observational Constraints on Dust Disk Lifetimes: Implications for Planet Formation

By Lynne A. Hillenbrand
[1]California Institute of Technology, MS 105-24, Pasadena, CA 91105, USA

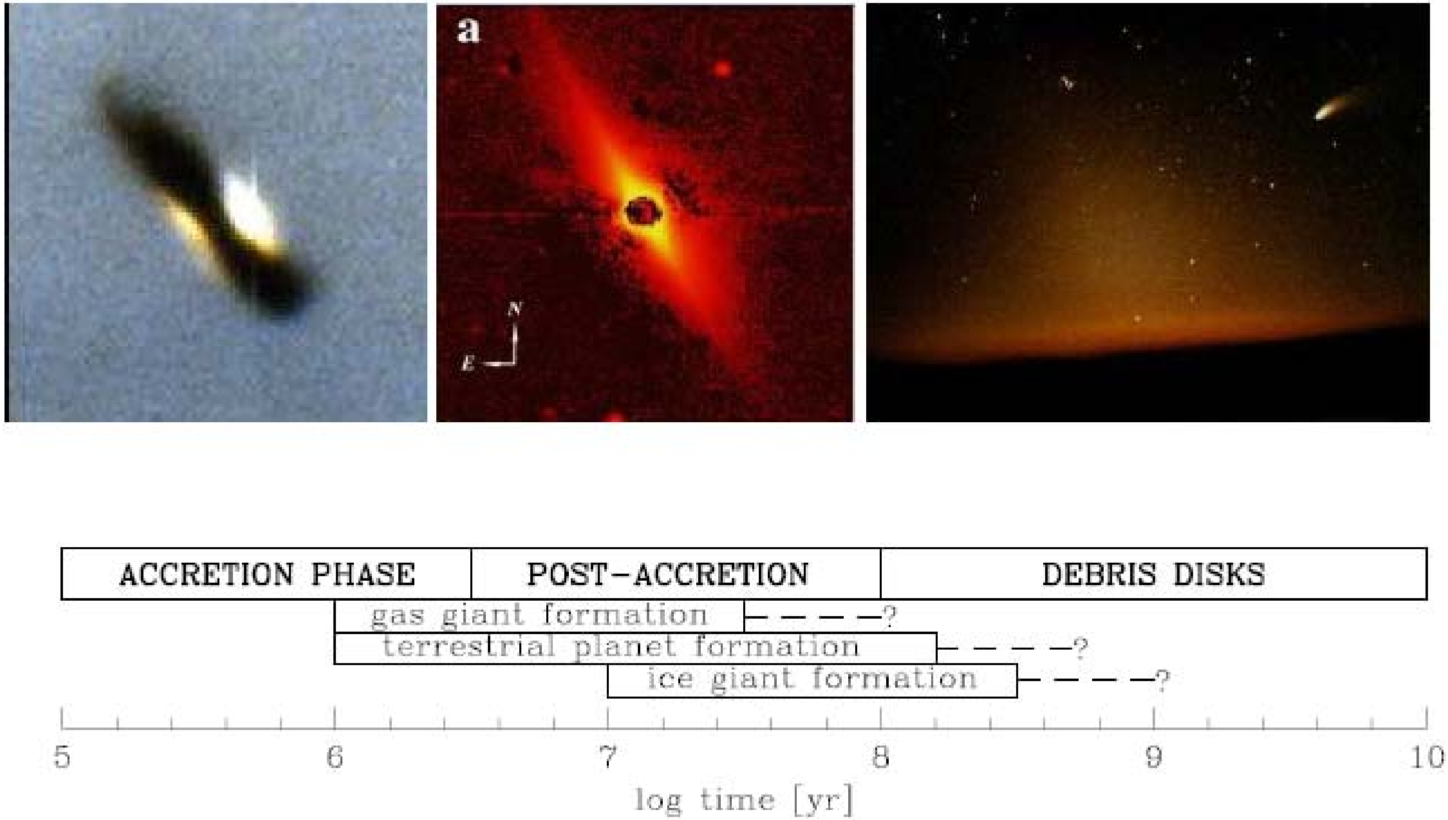


FIGURE 1. *Images of disks at various evolutionary stages scaled to a time line showing our general understanding of the basic phenomena.* Data are courtesy of J. Stauffer and B. Patten (left panel, Ori 114-426 optically thick "silhouette disk" as imaged with HST/WFPC), Kalas & Jewitt 1995 (middle panel, β Pic as imaged by a ground-based coronagraph), and P. Kalas (right panel, our own zodiacal dust disk along with a comet, as photographed from Calar Alto).

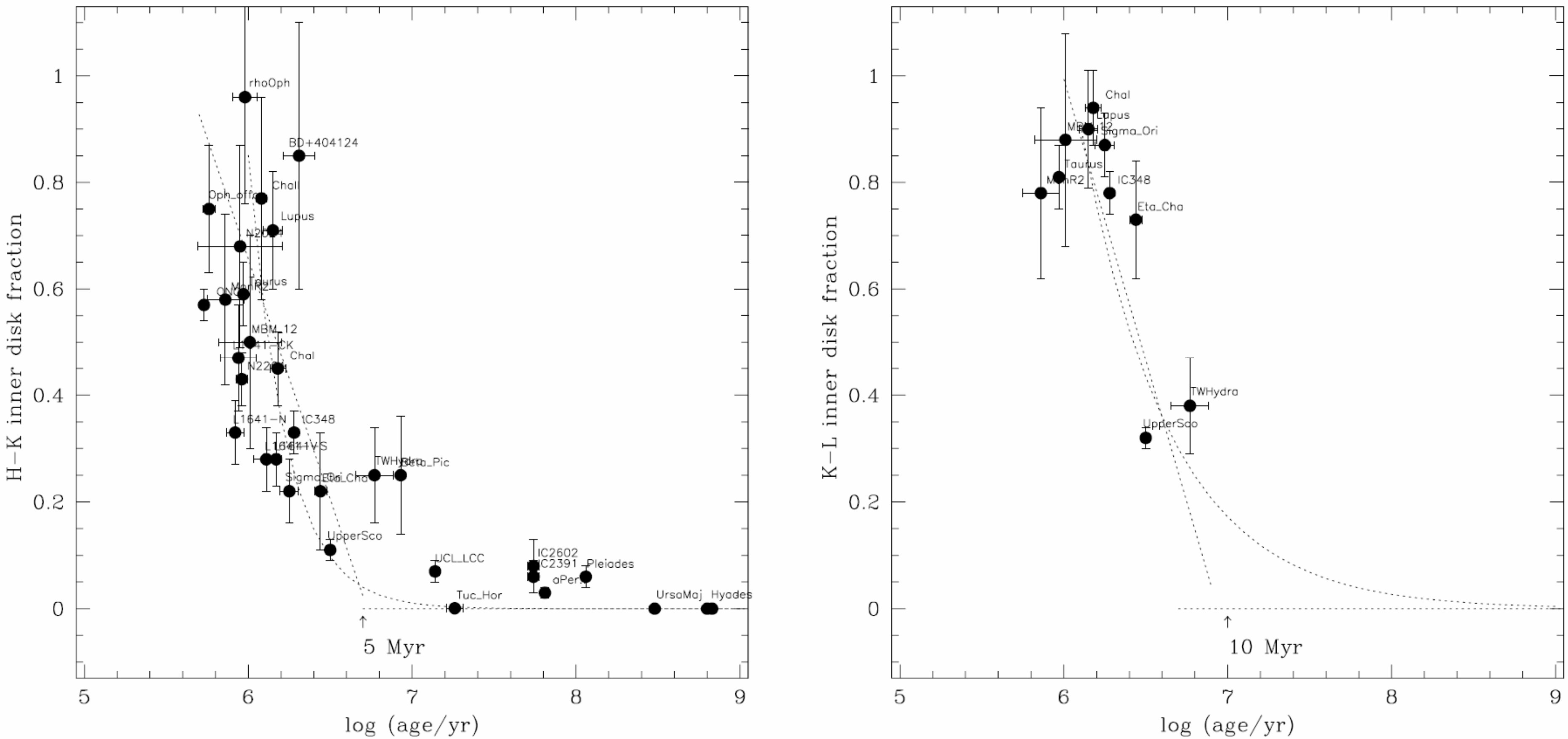
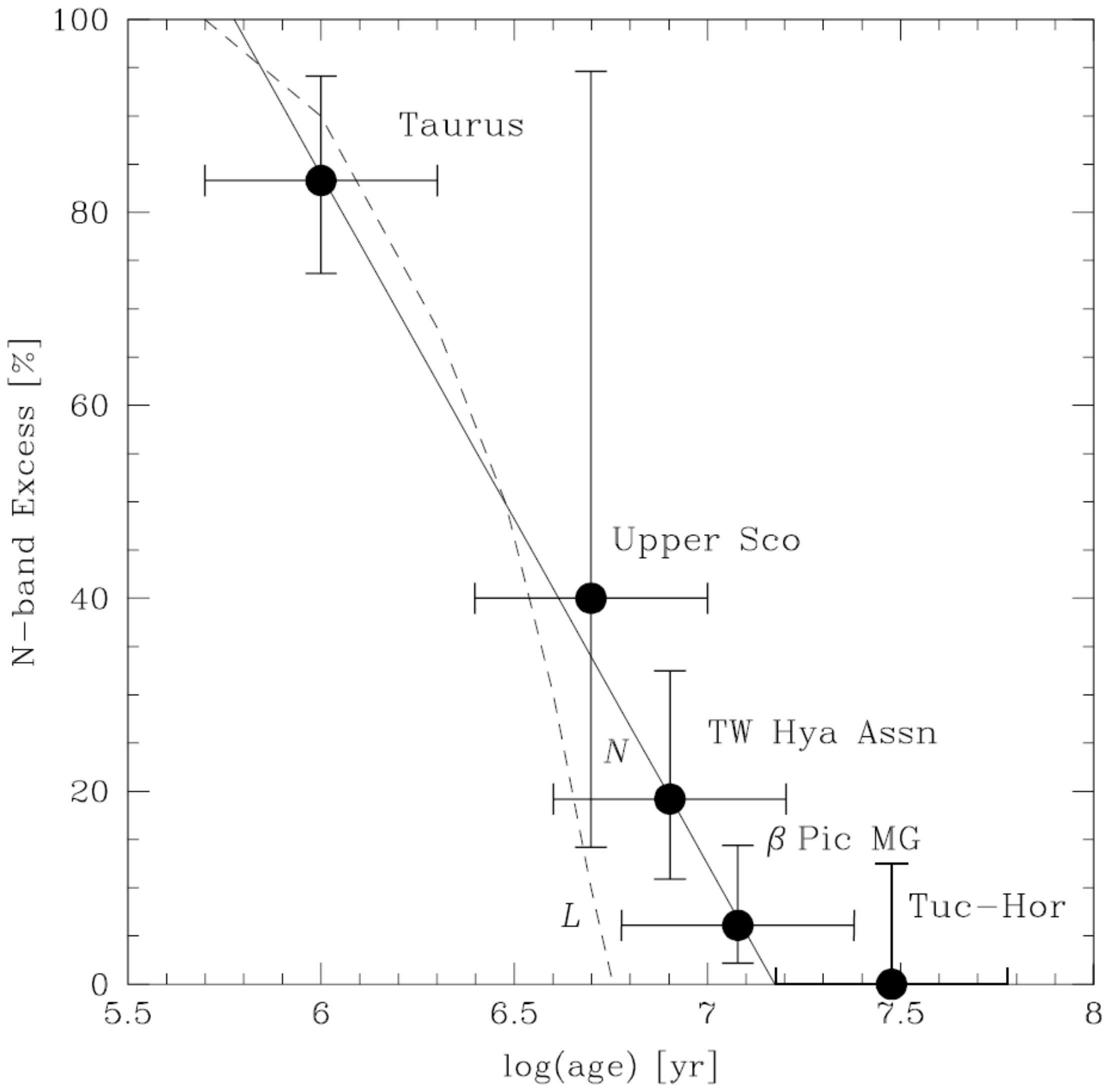


FIGURE 3. *Inner accretion disk fraction vs. stellar age* inferred from H-K excess (left panel) and K-L excess (right panel) measurements, binned by cluster or association. All young stars which we are able to locate in the HR diagram based on information in the literature (about 3500) and having inferred masses 0.3-1.0 $M_\odot$ are included in this figure. Individual clusters are treated as units of single age corresponding to the median age inferred from the HR diagram. A cut of Δ(H-K) > 0.05 mag is used to define a disk. Standard deviation of the mean (abscissa) and Poisson (ordinate) error bars are shown. The linear and exponential fits were derived for ages <30 Myr; the linear fit has negative slope close to unity with rms 0.3.



Terrestrial zone disk fraction vs. stellar age inferred from N-band excess measurements for ∼50 stars, taken from Mamajek et al 2004.

THE ASTROPHYSICAL JOURNAL, 612:496–510, 2004 September 1

CONSTRAINING THE LIFETIME OF CIRCUMSTELLAR DISKS IN THE TERRESTRIAL PLANET ZONE: A MID-INFRARED SURVEY OF THE 30 Myr OLD TUCANA-HOROLOGIUM ASSOCIATION

ERIC E. MAMAJEK, MICHAEL R. MEYER, PHILIP M. HINZ, AND WILLIAM F. HOFFMANN
Steward Observatory, Department of Astronomy, University of Arizona, 933 North Cherry Avenue, Tucson, AZ 85721; eem@as.arizona.edu

MARTIN COHEN
Radio Astronomy Laboratory, 601 Campbell Hall, University of California, Berkeley, CA 94720

AND

JOSEPH L. HORA
Harvard-Smithsonian Center for Astrophysics, 60 Garden Street, MS-65, Cambridge, MA 02138
Received 2004 March 16; accepted 2004 May 13

ABSTRACT

We have conducted an *N*-band survey of 14 young stars in the ~30 Myr old Tucana-Horologium association to search for evidence of warm, circumstellar dust disks. Using the MIRAC-BLINC camera on the Magellan I (Baade) 6.5 m telescope, we find that none of the stars have a statistically significant *N*-band excess compared to the predicted stellar photospheric flux. Using three different sets of assumptions, this null result rules out the existence of the following around these post–T Tauri stars: (1) optically thick disks with inner hole radii of $\lesssim$0.1 AU, (2) optically thin disks with masses of less than $10^{-6}\ M_{\oplus}$ (in ~1 μm sized grains) within $\lesssim$10 AU of these stars, and (3) scaled-up analogs of the solar system zodiacal dust cloud with more than 4000 times the emitting area. Our survey was sensitive to dust disks in the terrestrial planet zone with fractional luminosity of $\log(L_{\rm dust}/L_*) \sim 10^{-2.9}$, yet none were found. Combined with results from previous surveys, these data suggest that circumstellar dust disks become so optically thin as to be undetectable at *N* band before age ~20 Myr. We also present *N*-band photometry for several members of other young associations and a subsample of targets that will be observed with the *Spitzer Space Telescope* by the Formation and Evolution of Planetary Systems Legacy Science Program. Finally, we present an absolute calibration of MIRAC-BLINC for four filters (*L*, *N*, 11.6, and Q_s) on the Cohen-Walker-Witteborn system.

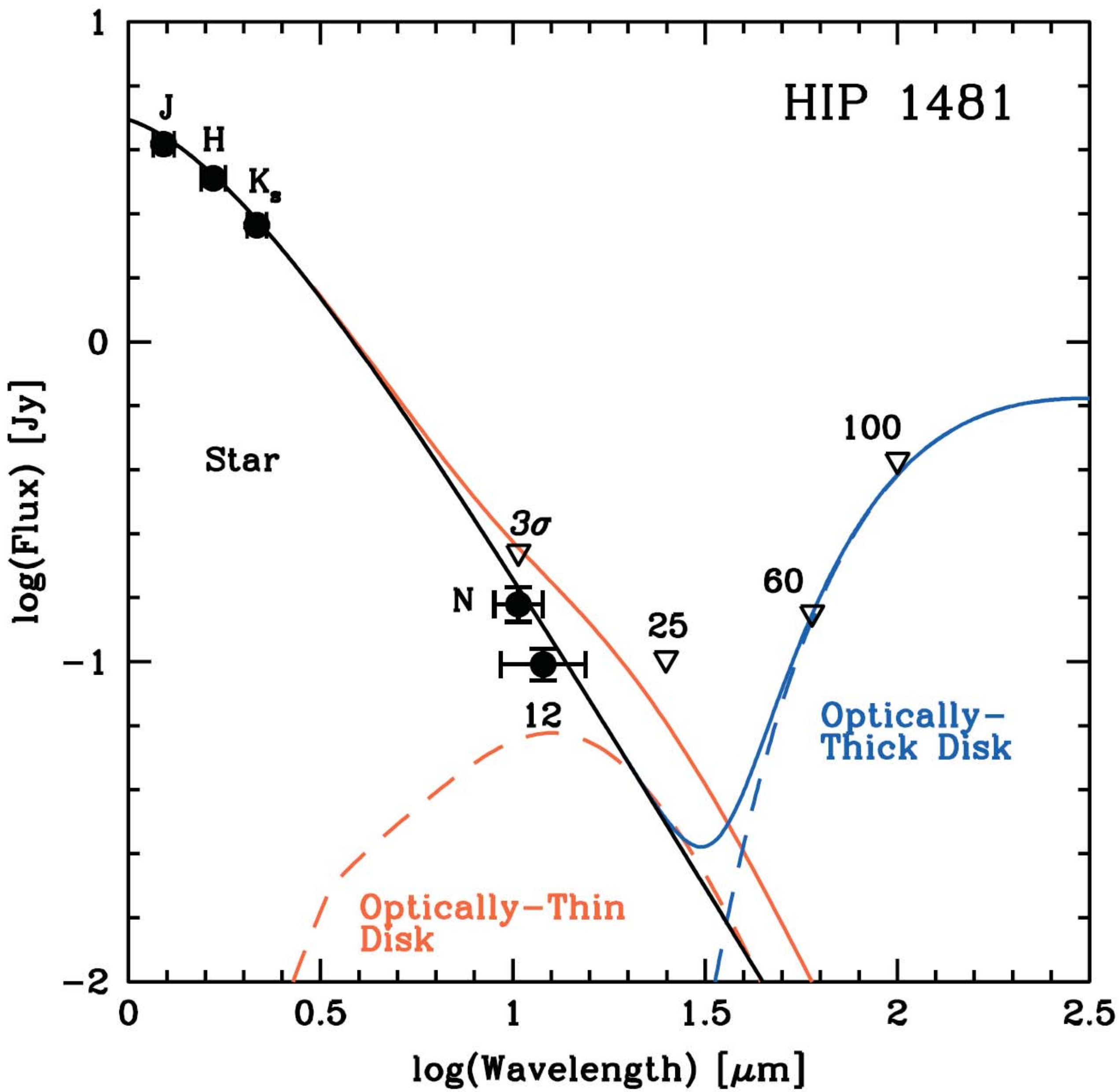
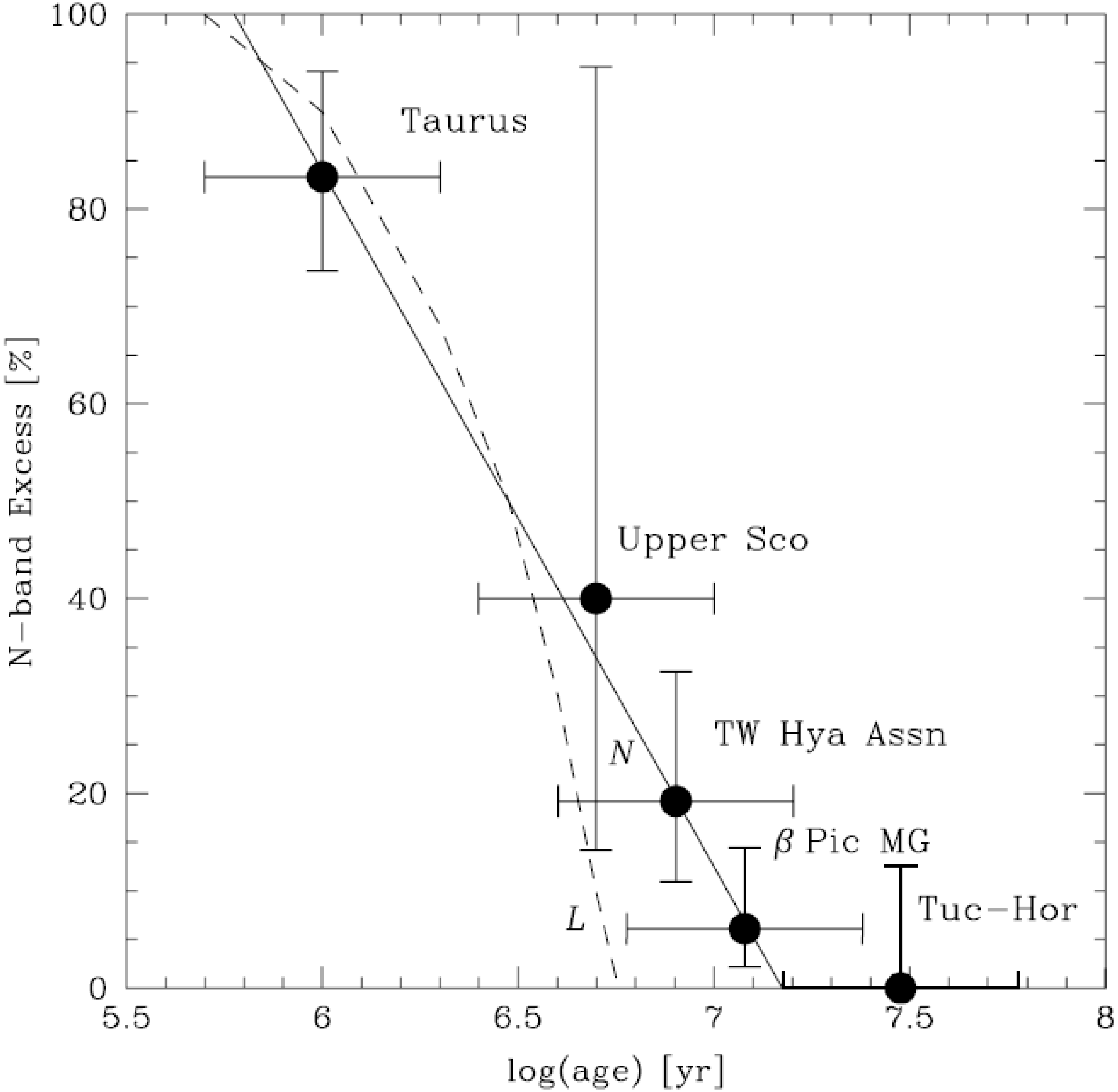

HIP 1481
J
H
K_s
Star
3σ
N
12
25
60
100
Optically-Thin Disk
Optically-Thick Disk
log(Flux) [Jy]
log(Wavelength) [μm]
1
0
−1
−2
0
0.5
1
1.5
2
2.5

FIG. 2.—Optically thin and thick dust models fitted to the MIRAC and *IRAS* photometry for a typical Tuc-Hor star (HIP 1481). If the star has an optically thick disk, its inner hole radius must be greater than 1.8 AU (constrained by *IRAS* PSC 60 μm upper limits). The stellar SED is approximated here as a 6026 K blackbody. The optically thin disk model is conservatively matched to 3 times the uncertainty in the *N*-band excess $E(N)$. The kink in the SED for the optically thin model occurs at $\lambda = 2\pi\bar{a}$ because of our simple treatment of dust emissivity (§ 4.2).



100
80
60
40
20
0
5.5
6
6.5
7
7.5
8
N-band Excess [%]
log(age) [yr]
Taurus
Upper Sco
TW Hya Assn
β Pic MG
Tuc−Hor
N
L

Fig. 3.—*N*-band excess vs. age for stellar samples of varying ages. Data are plotted for the following samples: Taurus-Auriga (Kenyon & Hartmann 1995), TW Hya association (Jayawardhana et al. 1999; Weinberger et al. 2003a), β Pic group (Weinberger et al. 2003b) and Upper Sco and Tuc-Hor (both in this study). Data from the *IRAS* study of AFGK-type field stars by Aumann & Probst (1991) show that *N*-band excesses among mostly older ($\gtrsim$100 Myr) field stars are extraordinarily rare ($\sim$0.2%). *Dashed line*: *L*-band disk fraction measured by Haisch et al. (2001a). *Solid line*: *N*-band disk fraction for the four youngest groups. It appears that *N*-band excesses are only detectable for timescales marginally longer than that of *L*-band excesses; however, the statistics are still poor. Note that in the TW Hya association, there exists a mix of optically thick and thin disks, while in the β Pic group, all of the known disks are optically thin.

A&A 450, 253–263 (2006)
DOI: 10.1051/0004-6361:20054372

Astronomy & Astrophysics

L-band (3.5 μm) IR-excess in massive star formation

II. RCW 57/NGC 3576⋆

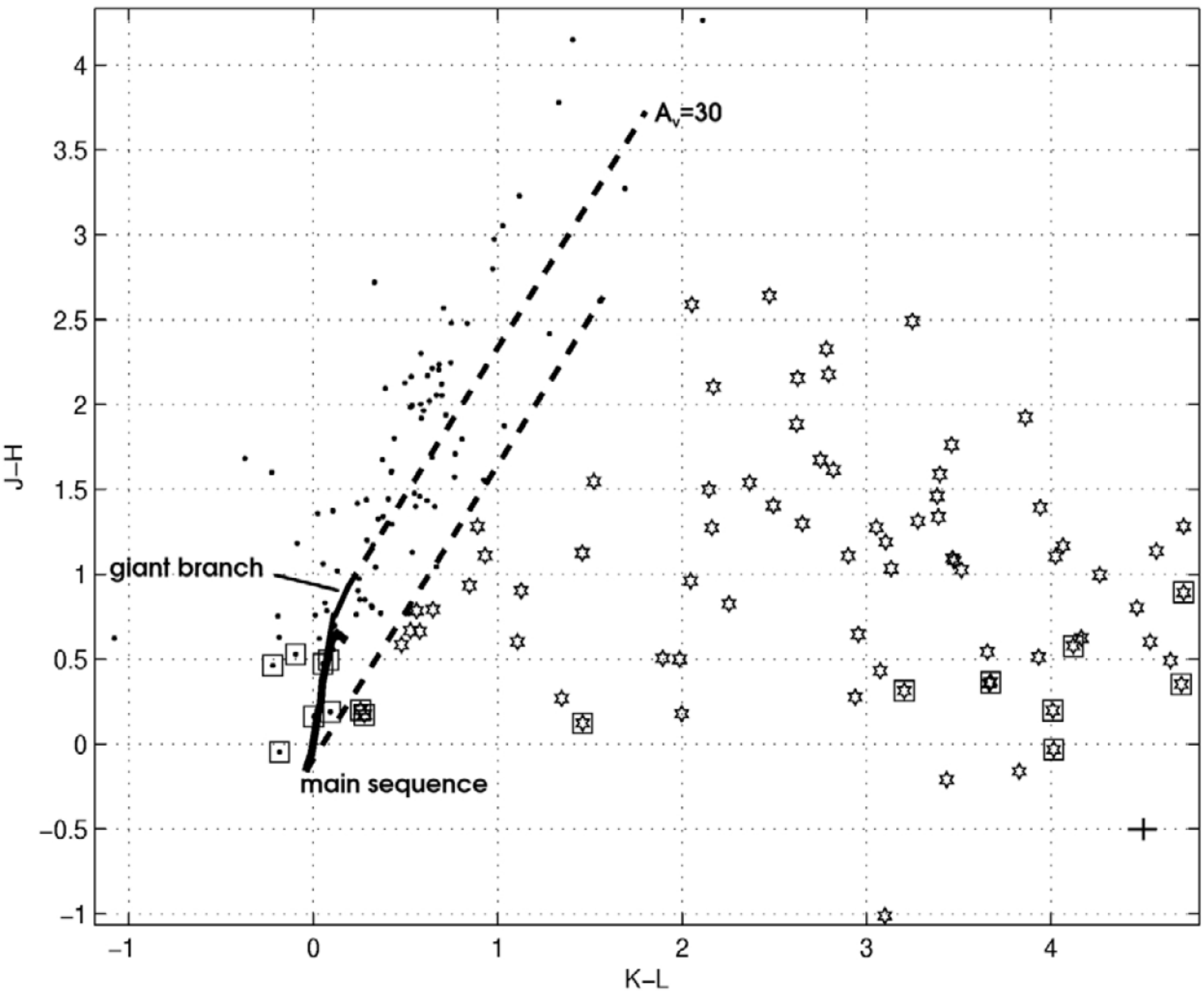
M. Maercker[1,2], M. G. Burton[2], and C. M. Wright[3]

[1] Stockholm Observatory, AlbaNova University Center, 106 91 Stockholm, Sweden
e-mail: maercker@astro.su.se
[2] School of Physics, University of New South Wales, Sydney, NSW 2052, Australia
e-mail: mgb@phys.unsw.edu.au
[3] School of Physical, Environmental and Mathematical Sciences, University of New South Wales@ADFA Canberra, ACT 2600, Australia
e-mail: c.wright@adfa.edu.au

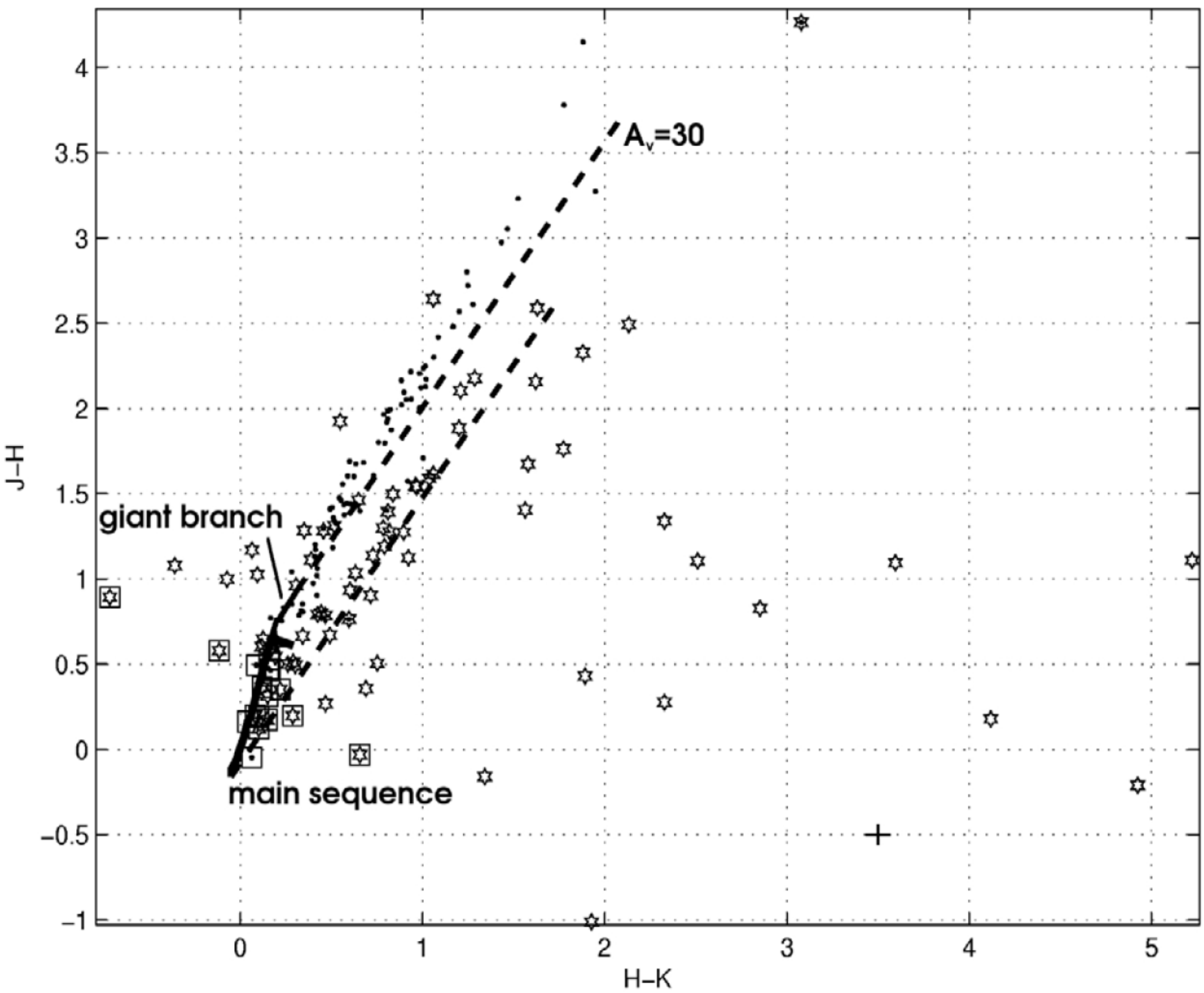
Received 18 October 2005 / Accepted 7 December 2005

ABSTRACT

Context. We present a JHK_sL survey of the massive star forming region RCW 57 (NGC 3576) based on L-band data at 3.5 μm taken with SPIREX (South Pole Infrared Explorer), and 2MASS JHK_s data at 1.25–2.2 μm. This is the second of two papers, the first one concerning a similar JHK_sL survey of 30 Doradus.
Aims. Colour–colour and colour-magnitude diagrams are used to detect sources with infrared excess. This excess emission is interpreted as coming from circumstellar disks, and hence gives the cluster disk fraction (CDF). Based on the CDF and the age of RCW 57, it is possible to draw conclusions on the formation and early evolution of massive stars.
Methods. The infrared excess is detected by comparing the locations of sources in JHK_sL colour–colour and L vs. $(K_s - L)$ colour–magnitude diagrams to the reddening band due to interstellar extinction.
Results. A total of 251 sources were detected. More than 50% of the 209 sources included in the diagrams have an infrared excess.
Conclusions. Comparison with other JHK_sL surveys, including the results on 30 Doradus from the first paper, support a very high initial disk fraction (>80%) even for massive stars, although there is an indication of a possible faster evolution of circumstellar disks around high mass stars. 33 sources only found in the L-band indicate the presence of heavily embedded, massive Class I protostars. We also report the detection of diffuse PAHs emission throughout the RCW 57 region.



A_v=30
giant branch
main sequence
J–H
K–L



J–H
H–K
A_v=30
giant branch
main sequence

affected by this consideration. Thus, the determined fraction of IR-excess sources is $55 \pm 2\%$. The JHK_s data alone (Fig. 8), would yield only 25 IR-excess sources, compared to 75 excess sources in the JHK_sL diagram. This would lead to a considerable underestimation of the CDF. Our JHK_s diagram looks