



A CHARA Array Survey of Circumstellar Disks Around Nearby Be-type Stars

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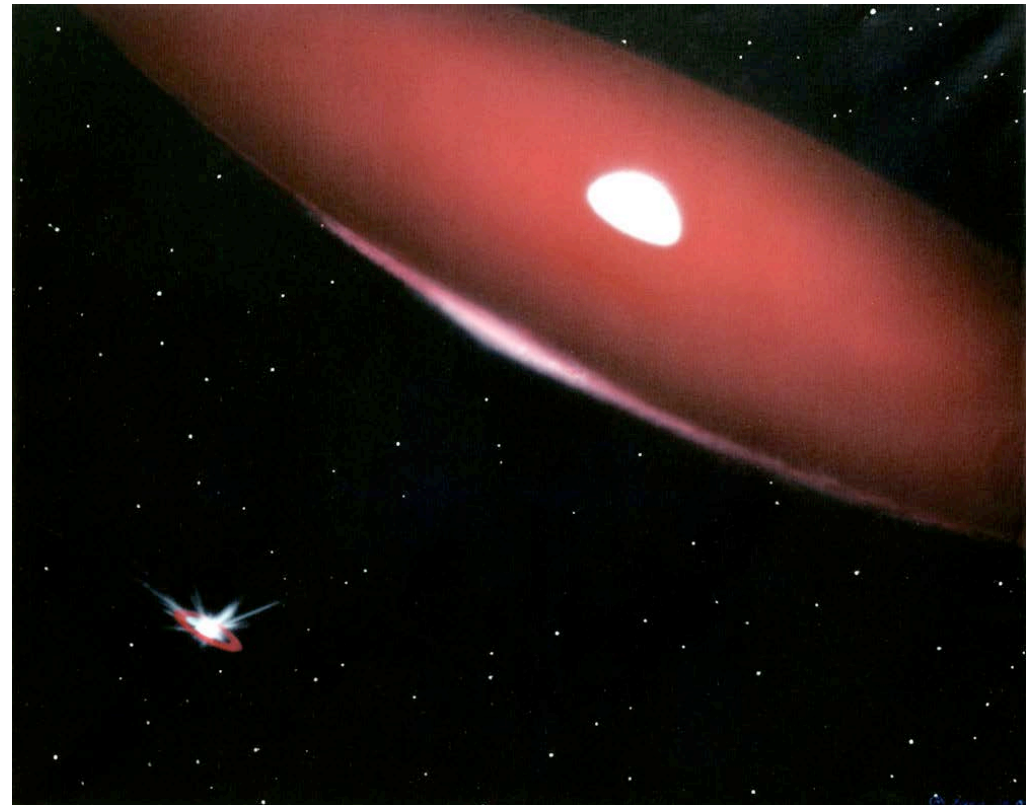
Surveying Be-Disks

- Rapidly rotating B-stars with ionized disks that produce continuum flux in IR from b-f and f-f emission
- Sample of 24 Be stars:
bright, relatively nearby, current H α emission
- Observations using:
 - + Interferometry
CHARA CLASSIC in the *K*-band
 - + IR Spectrophotometry
Lowell Obs. / Mimir and IRTF / SPEX
(Touhami et al. 2010, PASP, 122, 379)
- 563 bracketed observations mainly from 2007 October to 2010 November
- Usually S1/W1 and S1/E1 for better (*u,v*) coverage



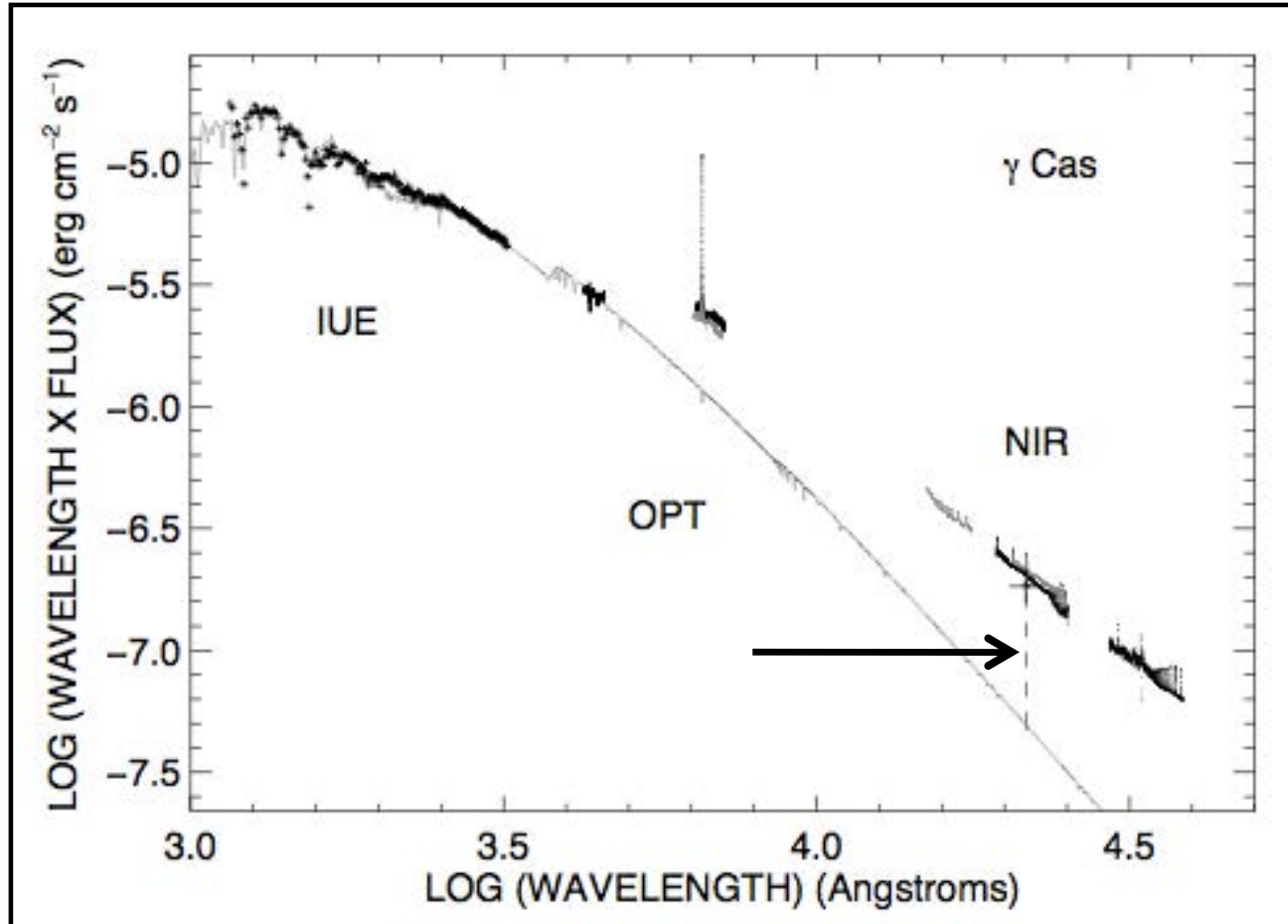
Binary/Multiple Star Corrections

- 14 of 24 Be stars have companions within CHARA FOV
- Normal stars and post- mass transfer remnants
- 9 of 14 are bright enough to affect visibilities
- Developed scheme to correct V based upon sep., PA, ΔK
- Renormalization of V in most cases





SED UV normalization: stellar angular diameter and NIR flux excess



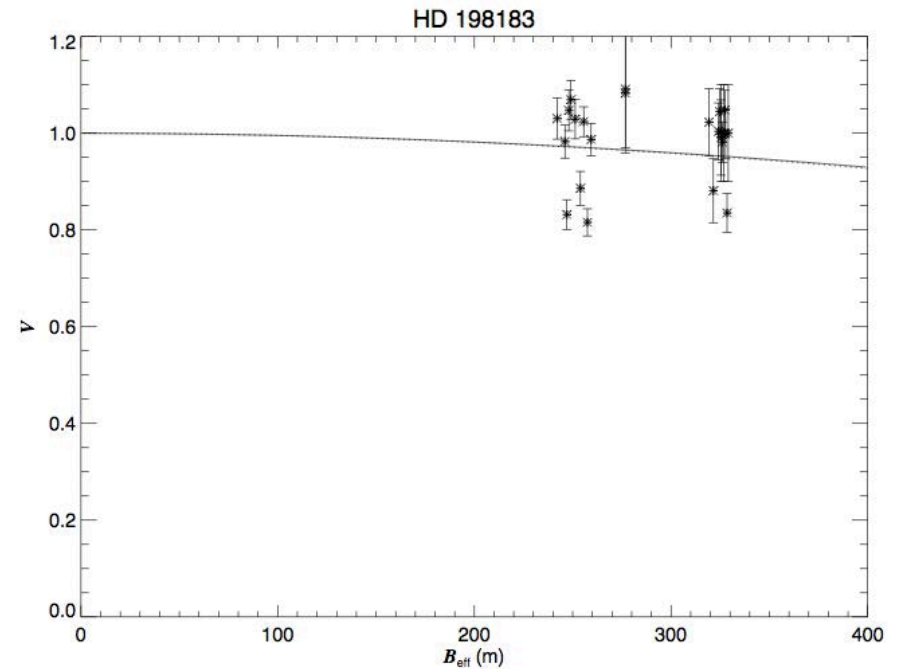
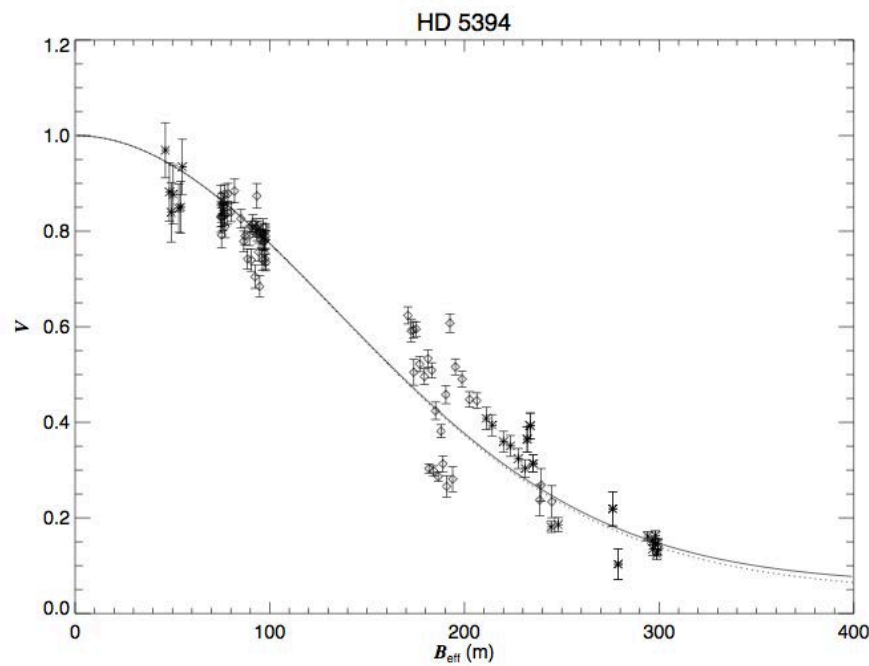


Gaussian Elliptical Model Fits

- $V_{tot} = c_p V_s + (1 - c_p) V_d$
- Used SED stellar angular diameter (small) for V_s (≈ 1)
- Disk visibility as Gaussian for major and minor axes with axial ratio r , position angle PA , and disk FWHM along major axis θ_{maj}
- Fraction of Gaussian disk flux falls upon star, so reassigned to the star: corrections for c_p and θ_{maj}



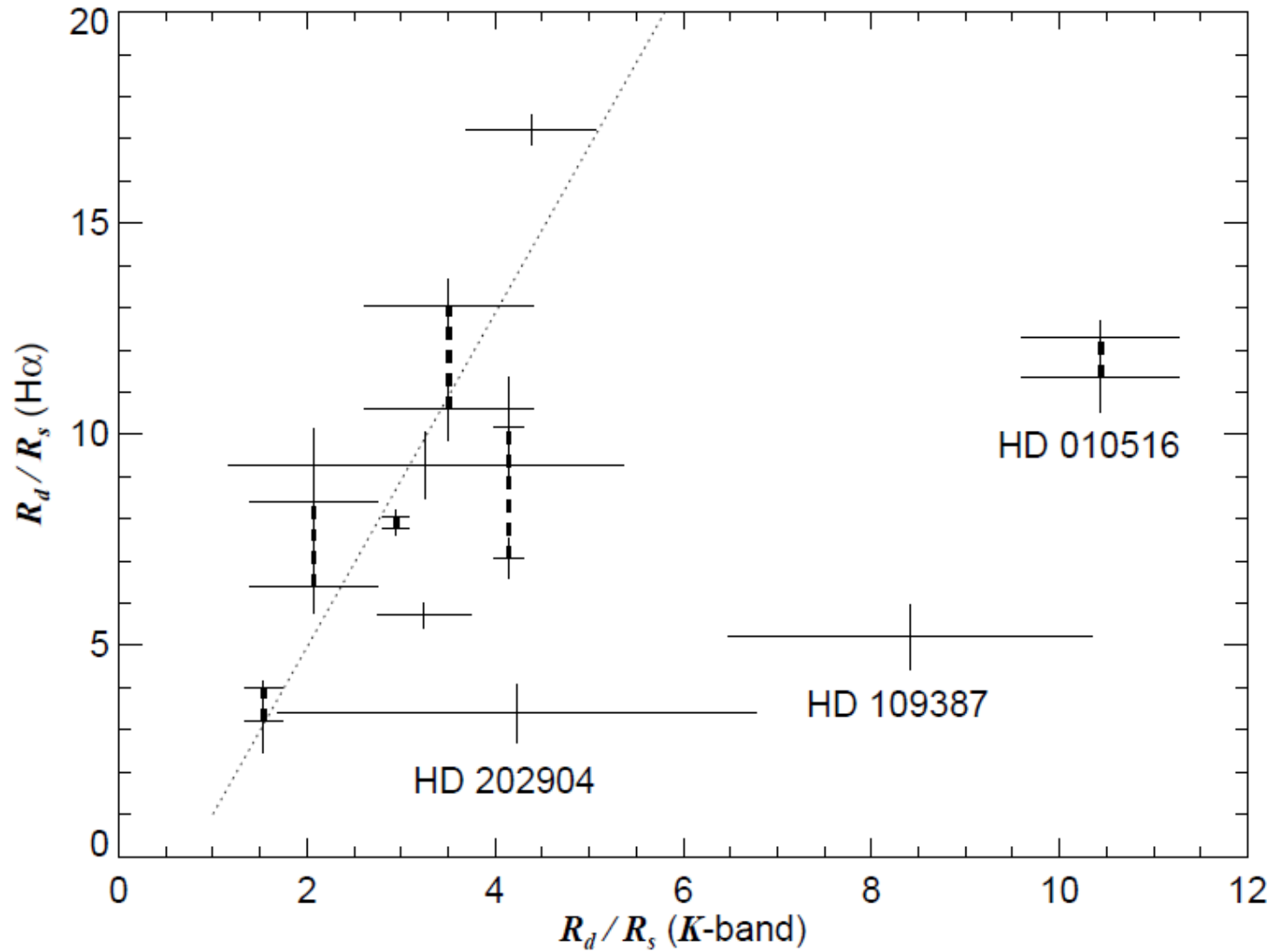
Survey Results: *14 Resolved, 6 Marginal, 4 Unresolved*





Survey Results

- Consistency between K -band flux excess from SED fits and GE model fits of interferometry
- Inclinations from minor - major axis ratio similar to those estimated from projected rotational broadening of spectral lines (Frémat et al. 2005, A&A, 440, 305)
- Disk normal orientation in sky consistent with linear polarization (corrected for interstellar polarization)
- Ratio of disk radius (half intensity) to stellar radius in range from 1.5 to 10 (mean = 4.4) in K -band, about 4 times smaller than for $H\alpha$ (higher opacity)



Observatoire de la COTE d'AZUR



Survey Results

- Use axial ratio to find $V(\text{equatorial})$ from $V \sin i \div \sin i$
 - ➔ most are very rapid rotators
 - $\langle \Omega_{\text{rot}} / \Omega_{\text{crit}} \rangle = 0.95 \pm 0.04$



Table 9. Linear Rotational and Critical Velocities

HD Number	$V \sin i$ (km s^{-1})	V_{crit} (km s^{-1})	V_{rot} (km s^{-1})	$V_{\text{rot}}/V_{\text{crit}}$	$\Omega_{\text{rot}}/\Omega_{\text{crit}}$
HD 004180	208 ± 13	332 ± 21	249 ± 26	0.75 ± 0.09	0.91 ± 0.06
HD 005394	441 ± 27	577 ± 36	599 ± 37	1.04 ± 0.09	≈ 1
HD 010516	462 ± 33	590 ± 42	487 ± 6	0.82 ± 0.06	0.96 ± 0.03
HD 022192	295 ± 15	397 ± 20	310 ± 70	0.78 ± 0.18	0.93 ± 0.11
HD 023630	149 ± 8	274 ± 15	216 ± 20	0.79 ± 0.09	0.94 ± 0.05
HD 025940	220 ± 13	386 ± 21	323 ± 82	0.84 ± 0.22	0.96 ± 0.10
HD 037202	326 ± 7	466 ± 13	333 ± 6	0.71 ± 0.02	0.89 ± 0.02
HD 058715	231 ± 14	380 ± 24	327 ± 91	0.86 ± 0.25	0.97 ± 0.10
HD 142983	407 ± 22	501 ± 28	484 ± 56	0.97 ± 0.12	1.00 ± 0.01
HD 202904	167 ± 20	468 ± 30	171 ± 7	0.37 ± 0.03	0.52 ± 0.04
HD 209409	282 ± 20	391 ± 27	288 ± 4	0.74 ± 0.05	0.90 ± 0.04
HD 217891	100 ± 6	367 ± 24	135 ± 44	0.37 ± 0.12	0.53 ± 0.16

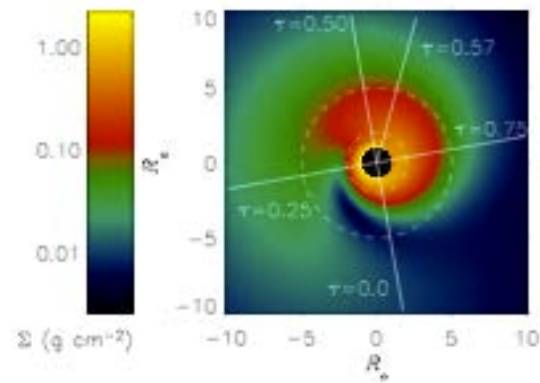


Work Underway

- Draft of papers on physical models for the disks of γ Cas and other Be stars
- Compare disk sizes between R -band (PAVO), H -band (MIRC), and K -band (CLASSIC/CLIMB)
- Search for secular variations in disk properties: development of asymmetries, formation, dissipation (Example of δ Sco at periastron: Che et al. 2012, ApJ, 757, 29; Meilland et al. 2013, A&A, 550, L5)
- Use closure phase observations (MIRC, CLIMB) to explore flux asymmetries caused by disk and faint companions (Schaefer et al. 2010, AJ, 140, 1838)



Disk Dynamics: *one-armed spiral pattern in ζ Tau*



Carciofi et al. 2009, A&A, 504, 915



MIRC 6T on ϕ Per

Che et al. 2012 (SPIE, 84450Z)

