Appendix B

Nearby Companions to Ae/Be Stars

One of the original motiviations for our deep infrared imaging program was to search for nearby, infrared-luminous companions to the Ae/Be stars. Concern regarding the presence of cool companions arises from the double-peaked structure of the Ae/Be spectral energy distributions in the optical/near-infrared. If present, companions could easily explain some fraction of the near-infrared excess and possibly remove the need to invoke nonstandard circumstellar disk geometries with inner disk holes (*cf.* Hillenbrand *et al.* 1992).

Historically, Ae/Be spectral energy distributions have been constructed from data obtained with single-channel optical and infrared photometers through apertures ranging up to 9 arcsec in size. Thus, in Table B.1 we present a list of Ae/Be stars with and without (blank entries) companions closer than 10 arcsec, as deduced from our near-infrared images and from the work of others (as referenced). We list the difference in K magnitude between the primary Ae/Be star and each companion (a difference of 2.5 magnitudes corresponds to a flux ratio of 10), as well as their separations in arcsec and in AU. Question marks are used to indicate unavailable information.

From Table B.1 we find that all companions resolvable from our imaging program ($\theta \gtrsim 2$ arcsec) are at least a factor of 10 fainter than their primaries. We conclude that "visual" binary companions do not provide enough flux to significantly contaminate the near-infrared spectral energy distributions.

However, the information obtainable from our imaging survey does not preclude the presence of candidate binary companions with separations less than a

Table B.1. Infrared Companions within 10 Arcsec

Ae/Be Star	Comp. #	ΔK mag	Δr arcsec	Δr AU	Reference/Comment
AB Aur	-	-	-	-	no speckle companions; Leinert *et al.* (1994)
BD +40° 4124	-	-	-	-	
	1	6.4	8.5	8500	
	2	6.9	9.0	9000	
	3	7.1	10.1	10,100	
BD +46° 3471	-	-	-	-	
	1	4.4	4.9	4500	
	2	4.7	5.9	5300	
BD +61° 154	-	-	-	-	possibly extended on our IR images
	-	-	-	-	speckle companion?
					single in HST data; Biuciarelli *et al.* (1993)
BF Ori	-	-	-	-	
Elias 1	-	-	-	-	extended in speckle obs.; Leinert *et al.* (1994)
	1	>2.5	4.0	640	this companion reported to be a radio source
					by Skinner, Brown, & Stewart (1993)
HD 200775	-	-	-	-	
	1	4.9	2.3	1400	
	2	6.5	5.5	3300	
HD 245185	-	-	-	-	
	1	6.0	8.0	3200	
HD 250550	-	-	-	-	single in HST data; Biuciarelli *et al.* (1993)
HD 259431	-	-	-	-	
HK Ori	-	-	-	-	
	1	<0.0	0.3	150	Leinert *et al.* (1994)
KK Oph	-	-	-	-	
	1	2.1	2.4	380	Leinert *et al.* (1994)
LK Hα 25	-	-	-	-	
	1	2.4	10.0	8100	
LK Hα 198	-	-	-	-	bright extension in speckle obs.; Leinert *et al.* (1991)
	1	3.3	5.7	3400	
LK Hα 208	-	-	-	-	
LK Hα 215	-	-	-	-	
	1	4.4	8.4	6700	
LK Hα 218	-	-	-	-	
LK Hα 233	-	-	-	-	bright extension in speckle obs.; Leinert *et al.* (1993)
LK Hα 234	-	-	-	-	
	1	3.2	3.1	3100	
	2	3.8	4.0	4000	
	3	4.9	8.0	8000	

Table B.1.

Table B.1. Infrared Companions within 10 Arcsec (continued)

Ae/Be Star	Comp. #	ΔK mag	Δr arcsec	Δr AU	Reference/Comment
MWC 137	-	-	-	-	
	1	>4.0	5.1	6600	
	2	>4.8	6.3	8200	
	3	>4.5	6.6	8500	
	4	>4.8	7.3	9400	
	5	>4.8	8.2	10,600	
MWC 297	-	-	-	-	
MWC 1080	-	-	-	-	highly extended at 10μm; Deutsch (private comm.)
	1	?	?	?	eclipsing system; Grankin *et al.* (1992)
	2	3.4	0.8	750	Leinert *et al.* (1994) (could be same star as #1)
	3	3.1	5.1	5100	
	4	3.5	6.9	6900	
	5	8.1	8.2	8200	
	6	8.3	9.3	9300	
NX Pup	-	-	-	-	
	1	1.8	0.1	450	Brandner *et al.* (1994); Biuciarelli *et al.* (1993)
	2	4.0	7.0	3200	Brandner *et al.* (1994)
R CrA	-	-	-	-	faint extension in speckle obs.; Leinert *et al.* (1994)
R Mon	-	-	-	-	bright extension in speckle obs.; Leinert *et al.* (1994)
RR Tau	-	-	-	-	
T Ori	-	-	-	-	
	1	?	?	?	duplicity in optical claimed by Shevchenko *et al.* (1994)
	2	>4.5	7.7	3500	could be same star as #1
TY CrA	-	-	-	-	-
	1	?	?	<0.1	Casey *et al.* (1993), Lagrange *et al.* (1994) (eclipsing system)
UX Ori	-	-	-	-	
V376 Cas	-	-	-	-	bright extension in speckle obs.; Leinert *et al.* (1991)
V380 Ori	-	-	-	-	
	2	1.3	0.2	760	Leinert *et al.* (1994)
V856 Sco	-	-	-	-	
	1	3.5	1.5	240	Stecklum *et al.* (1994)
V1686 Cyg	-	-	-	-	
	2	6.4	4.6	4600	
	1	5.7	9.1	9100	
VV Ser	-	-	-	-	faint extension in speckle obs.; Leinert *et al.* (1994)
	1	>5.0	7.8	3400	

few arcsec. These are detectable only via infrared speckle techniques, with which resolutions as high as 0.1 arcsec can be achieved. Although an exhaustive survey of the Ae/Be population has not yet been completed, we do note in Table B.1 the existence of references to speckle companions where they are known. Interestingly, the speckle-resolved companions are typically brighter than those resolvable from standard imaging techniques, an effect we show graphically in Figure B.1. This trend is partially explainable in that the dynamic range of speckle imaging is restricted to about 4 magnitudes; thus faint companions will not be detected. However, there is still a paucity of bright companions with separations larger than 1000 AU compared to those with separations less than 1000 AU. Leinert *et al.* (1994) make a preliminary estimate that more than 20% of all Ae/Be stars may have bright companions within the range 75-750 AU.

Until accurate information on magnitude differences and radial separations is assembled for individual sources, no global conclusions can be made regarding the effects of companions on the Ae/Be spectral energy distributions. We also note in Table B.1 cases in which extended structure at near- or mid-infrared wavelengths of the Ae/Be star has been reported.

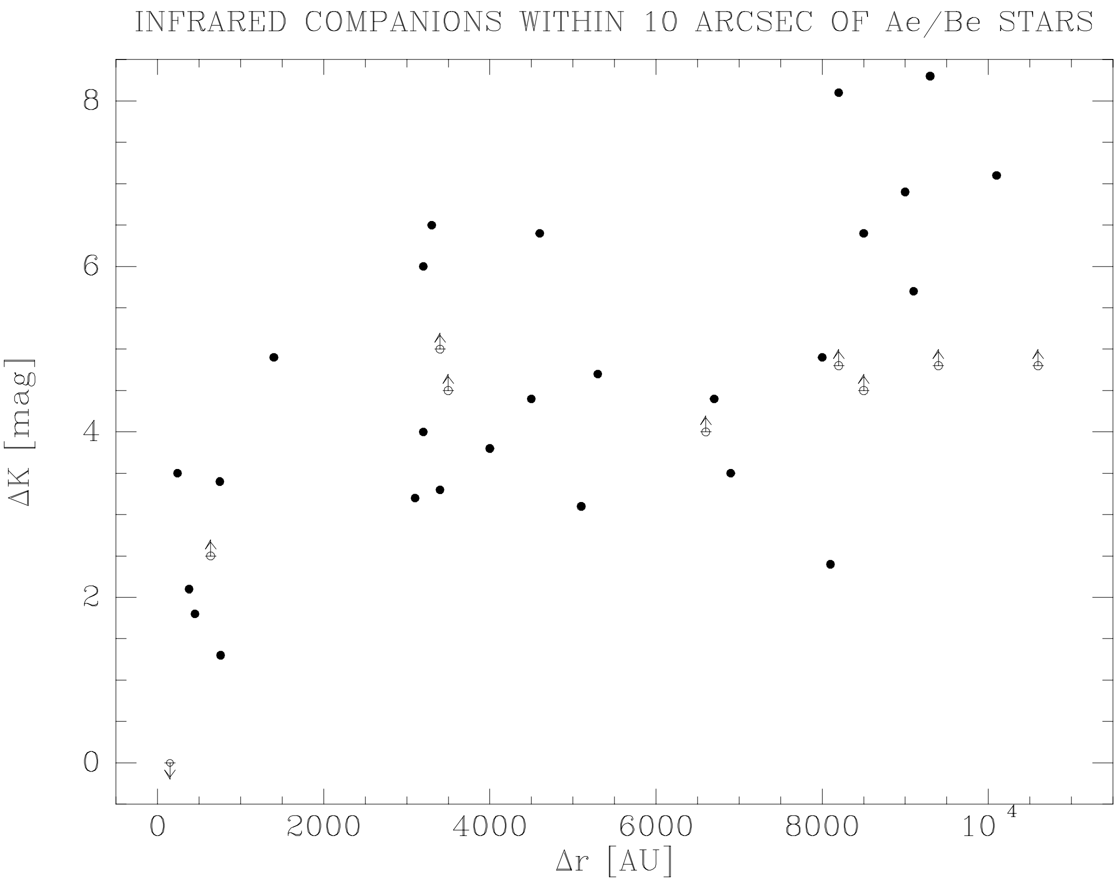

Figure B.1. *Infrared flux ratio versus separation for nearby companions.* Stars projected within 10 arcsec of Ae/Be stars are shown as a function of magnitude difference at K. Lower (and one upper) limits are indicated. We note that the brightest companions are those with the smallest physical separations.