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1 (VLTI-)Relevant observational facts about Be stars

1.1 K magnitudes

Be Stars with K brighter than 2 are not too numerous, in fact there is α Eri in the southern hemisphere and that's it. Next are γ Cas (too north) and α Col (2.5). Because all bright Be stars are main sequence B stars close nearby, there is basically no reddening and you may expect colour terms close to zero. If no K magnitudes are available, the magnitudes at shorter wavelengths are only slightly brighter, if at all. Only very expectionally there might be IR excess in K more than .3 mag.

1.2 Spectral emission lines in the K Band

The band basically hosts two spectral lines of significant emission strength in Be stars (i.e. maximally higher than a factor of two above the continuum). These are He I 2.058 and Brγ. This He line has the metastable lower singlet level common with 5016 Å, and its upper level is the lower level for the 6678 and 7281 transitions, but might also be populated by He II recombination. This means in a shell star I'd expect strong absorption in front of it, while the line should be in emission throughout the disk otherwise. See Clark&Steele (2000, AAS 141, 65) for examples of spectra.
There is a possibility that the K band continuum is optically thick for stars with strong disk. Then you may expect disk sizes of up to 40 stellar radii. γ Cas is probably such an example.

1.3 Polarization

For almost all Be stars, the paper by Yudin (2001, AA 368, 912, appendices at VizieR) is a good compilation of polarization data. Since the disk is equatorial, the intrinsic polarization angle is parallel to the rotation axes! Other things given by this author, like $v \sin i$ are less reliable for individual objects, although the rotational velocity statistics is probably still ok.

1.4 Spectroscopy

It would probably be very worthwhile to obtain an optical spectrum more or less simultaneously (where in the same night would be perfect, but more than a week might be problematic for the comparison). Since the targets are bright, this should be possible with UVES in the twilight without operational losses, even in visitor mode (Note: I say this from my experience as UVES support astronomer, but this is nothing official of course). Typical exposure times would be 1 to 10 seconds. There are few such bright star spectra already of the Be stars δ Sco or HR 4009, for example. FEROS would be ok as well, of course, but there is no Science Operations astronomer for the ESO 1.52m.

2 Potential applications

2.1 Rotational flattening and gravity darkening

A star rotating critically would have a $R_{\rm pole}/R_{\rm eq}$ ratio of 1/1.5. The rotational rates of Be stars peak quite sharply at about 70 to 80% of the critical rotation rate $\omega = v_{\rm rot}/v_{\rm crit}$. For a star rotating at 80% critical, the ratio is about 1/1.2 to 1/1.3.

$$\frac{R_{\rm pole}}{R_{\rm eq}} = 1 - \frac{\omega^2}{3}$$

On the other hand, such a star is subject to gravitational darkening. The lower effective gravity at the equator leads to a lower temperature there. It is not entirely clear if the "traditional" gravity darkening law by von Zeipel (1924)

$$T(\vartheta) = T_{\rm pole}\frac{\log g(\vartheta)}{\log g_{\rm pole}}^{0.25}$$

is correct (the hard point is the exponent), but if so a star at 75% critical and 23kK $T_{\rm pole}$ would have only about 18kK at the equator. In any case, the higher ω, the cooler (and dimmer) the star is at the equator. However, there have been advocates doubting that gravity darkening is that strong. Since, then, the largest radius (equator) is also the dimmest one, this might be problematic for flattening measurements. Would this intensity contrast be a problem for the interpretation, or rather a chance for something to be measured?
Bright Be-shell stars are seen equator-on through the disk, so we can rely on $\sin i = 1$ for them. Also, polarimetric measurements during emission/shell phases should give us the rotation axis orientation of the star. However, currently inactive stars or stars with a weak disk would be preferred for this kind of measurement, in order to minimize the confusing power of the disk emission.
One potential object is ν Pup (K=3.4 mag), a very weak, but undoubtedly shell star of sp.type B8 III, v sin of about 230 km/s. Unfortunately, I am not aware of polarization measurements to obtain the orientation of ν Pup. A reasonable $v_{\rm crit.}$ for this spectral type is 320 km/s, which gives $\omega = v_{\rm rot}/v_{\rm crit.}$ to be 71%. The Hipparcos parallax is $7.71 \pm .52$ mas. Then, assuming 5 $\rm R_{sol}$ as polar radius, the apparent diameters would be 0.44 and 0.53as (pole, equator). Is this difference too close to the error bars (about 0.05 mas according to press release)? Other stars with similar numbers, but stronger disks, are o Aqr and ω Car.

2.2 Vertical disk geometry

Be stars are thought to have Keplerian disks. The vertical structure of gaseous Keplerian disks is (by theory) characterized by increasing opening angle with distance from the star. In other words, the scale height of the disk increases faster than linear with the radius ($H \propto R^{3/2}$). This is called the "flaring of the disk". I'm not sure, but for large distances and radio bands I think this has been observed already (not for Be stars, though). At the same time, the density of the disk goes like $\rho \propto R^{1/2}$ (the exponent being a rough estimate only), so that the overall density profile looks like given by Hanuschik (1996, AA 308, 170).
Best suited to observe this effect would be strong shell stars: They are seen edge on and have strong disks. Examples would be ζ Tau, 48 Lib, and β^1 Mon. All these stars could have optically

thick disks in K. Interesting here are vertical density profiles depending on radius, about up to 20 stellar radii. However, the disk out there could be so dim that I'm not sure if it can be observed with sufficient contrast.
Given the limited choice of baselines at the moment, is there a preferable PA of the disk? If so, pls. keep in mind that the intrinsic polarization angle is perpendicular to the disk.

2.3 Ring or disk dimensions/gaps

Be stars form/replenish the disks in outbursts, i.e. occasional ejections of matter. The typical timescale between outbursts differ from weeks to years. When a disk has formed and is then left alone, it starts to be dissolved by the stellar radiation. During this process, the disk migrates outwards, leaving a "gap", or more accurate a density minimum, between the stars and the inner disk edge. This gap might be as wide a one stellar radius. During the next outburst, it is filled again with gas. In some cases, if the gap was wide enough before the outbursts, it is not completely filled up and two separate rings coexist for a while, until they merge (the outward motion is more rapid for freshly ejected material, which is more dense).
Preferred targets would be pole on stars, in which the disk and the gaps look circular. There are only few with substantial parallaxes, ω CMa, β Psc, μ Cen, maybe FW CMa and 31 Peg. Indication for gaps have been observed spectroscopically in FW CMa and μ Cen, a double ring structure in ω CMa.
The most practical strategy to look for gaps would be to obtain spectroscopy of a sample beforehand (say 2 nights with FEROS) and then catch the most promising one(s) with VLTI. This needs some preparation and is probably better suited for a regular programme than for commissioning.
On the other hand, ω CMa is currently undergoing the strongest outburst since Hipparcos (the satellite) times (see IBVS 5193) and will unlikely do this again in the next five to ten years. Significant changes should become apparent if followed occasionally for some time. Therefore, right now is an excellent oppotunity which we may not have again soon. Since the outburst is ongoing, there is certainly no gap, which would develop only if the star is quiet for a couple of months at least. But the disk around ω CMa is probably optically thick in K at the moment (this seems to be the case even in the visual), and this will change within some months.

2.4 Law of rotation

Not a VINCI project
The rotational velocity in a Be star disk goes with radius like $v \propto R^\beta$ for any reasonable velocity law. For a Keplerian disk $\beta = 0.5$, for conservation of momentum $\beta = 1$. So what needs to be measured is the wavelength offset (projected velocity) of strong line emission as a function of the distance to the star. This is not too urgent right now to be worked out, since we'll need spectroscopic resolving power of say R=3000 to 5000 or so. Strong shell stars as for the vertical structure would be preferred as targets. Again, targets would be probably be ζ Tau, 48 Lib, β^1 Mon, but only if the K band is not optically thick.
There's a paper by Stee (1996, AA 311, 945) discussing spectrally resolved intensity maps for the (modeled) example of γ Cas. Connected to this, but without spectral dispersion are things like the long term V/R variability. It is basically a density enhancement in the disk (individual particles are in elliptic orbits with a common periastron), which is precessing around the star in

a decade or so. Such things have been observed in ζ Tau (Vakily et al., 1998A&A...335..261V) and γ Cas (Berio et al., 1999A&A...345..203B) as "photocenter offsets" with variable position angle. ζ Tau and 48 Lib are prime examples for such V/R variability.

2.5 β Ori

Not a VINCI projct

Only very exceptionally the Hα emission is 20 % of the continuum. Most times it is 5 to 10 %. I assume Brγ emission is not brighter, and I am not sure if such a contrast would be detectable, unless it is spectroscopically resolved (i.e. very narrowband). This means before working out details, I'd like to talk to A. Kaufer, who did (part of) his PhD-thesis on β Ori.

Appendix: Objects

Only the projects rotational flattening (2.1), vertical disk geometry (2.2), and one object for outbursts (2.3) make sense with the current setup (VINCI).

Table 1: Note that especially the stellar radii are 0^{th} order estimates and might be very wrong. E.g. for α Eri any radius estimated from spectral type (B3 V to B4 IV) would be too small compared to the derived 1.9mas. Since we do not have any solid idea about the inclination of α Eri's rotation axes, I have not included it in the list below.

Name	η Cen	ϵ Cap	27 CMa	o Aqr	ω Car
HD number	127972	205637	56014	209409	89080
RA	14 35 30	21 37 04	07 14 15	22 03 18	10 13 44
Dec.	-42 09 28	-19 27 57	-26 21 09	-02 09 19	-70 02 16
Sp. Type	B2 IV	B3 III	B3 III	B7 III	B8 III
intr. pol. PA (|| to rot.)	172	156	76	6	38
$v \sin i$[km/s]	350	250	350	260	220
$\omega = v_{\mathrm{rot}}/v_{\mathrm{crit.}}$	0.83	0.68	0.82	0.75	0.68
$R_{\star,\mathrm{pole}}$ [$\mathrm{R}_\odot$]	9.0	8.0	8.0	5.5	5
flattening	1.30	1.18	1.28	1.23	1.18
K [mag]	3.0	4.7	4.7	3.9	3.3
parallax [mas]	10.57	4.92	2.07	8.56	8.81
est.app.diam. [mas]	0.89	0.36	0.15	0.44	0.41
project	2.1	2.1	2.1	2.1	2.1
priority	1	3	3	2	2
Name	ν Pup	ω CMa	ζ Tau	48 Lib	β^1 Mon
HD number	47670	56139	37202	142983	45725
RA	06 37 45	07 14 48	05 37 38	15 58 11	06 28 49
Dec.	-43 11 45	-26 46 21	+21 08 33	-14 16 45	-07 01 59
Sp. Type	B8 III	B2.5 IV	B1 IV	B3 IV	B4 Ve
intr. pol. PA (|| to rot.)	–	25	34	162	14
$v \sin i$[km/s]	230	100	320	400	300
$\omega = v_{\mathrm{rot}}/v_{\mathrm{crit.}}$	0.71	–	0.68	1.00	0.69
$R_{\star,\mathrm{pole}}$ [$\mathrm{R}_\odot$]	5.0	7.0	5.5	7	5
flattening	1.20	–	1.18	1.50	1.19
K [mag]	3.4	4.0	3.0	4.5	3.8
parallax [mas]	7.71	3.53	7.82	6.36	4.72
est.app.diam. [mas]	0.44	0.23	0.40	0.42	0.22
project	2.1	2.3	2.2	2.2	2.2
priority	1	1	3	2	1