AMBER+FINITO+UT Science Demonstration Proposal

Title: Are all LBV's fast rotators?

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Abstract:

Until now only one LBV – η Carinae – has been observed with the VLTI. However, the advent of FINITO with the UT's opens the possibility to resolve other members of this exclusive class and thus to better understand the physics of these massive stars near the end of their lives. None of the bona-fide LBV's, which are in fact very few, can be observed with the VLTI (for different reasons), but some LBV candidates can. The aim of this proposal is to observe Wra17-96, which is one of the most luminous LBV's (candidates) known with a luminosity similar to that of the prototypical LBV AG Car. Wra17-96 has a rich emission line spectrum typical of LBV's and, at a distance of about 4.5kpc and a K magnitude around K=5, is an ideal object to compare with the detailed VLTI observations of η Carinae available in the literature, through observations with AMBER in HR mode.

Scientific Case:

Massive stars go through an brief albeit extremely imporant unstable phase in their evolution characterized by eruptive variablity at basically all time scales observed. During this so-called Luminous Blue Variable (LBV) phase, massive supergiants span a broad range of effective temperatures at basically constant bolometric luminosity and therefore effectively cross the HR diagram horizontally from side to side. The prototypes of this class are P-Cygni, the first one discovered, and the famous η Carinae, one of the most luminous stars in the Milky Way. LBV's are generally associated with bi-polar nebulae (e.g. the Humunculus around η Car) and this has historically led observers to assume that the LBV phenomenon is associated with binarity or rotation (e.g. Langer et al., 1999 and references therein). However, it was not until the models of Owoki and collaborators were published (see e.g. Dwarkadas & Owoki, 2002 and references therein) that the puzzling alignment between the stellar rotation vector and the major axis of the bi-polar nebula was understood. Since Owoki's gravity-darkening models only work if the stars rotate close to the breakup or critical velocity, several authors have proposed that the LBV phase is characterized by stellar rotation at a significant fraction of the critical velocity (e.g. Groh et al. 2006 and references therein). In fact, there is substantial observational evidence that at least some LBV's are rotating very fast – up to 90% of the breakup velocity in the case of η Car (van Boekel et al., 2003).

These characteristics make LBV's very interesting targets to be studied with interferometers, but until now it has only been possible to observe the η Carinae with the VLTI. The advent of FINITO on the UT's opens up the field to study other stars, and therefore to verify the inferences upon the class that have been made largely from observations of η Carinae and perhaps one or two other objects. To be sure, there are several fascinating objects that could in principle be studied by VLTI: the Pistol star, FMM362 in the same cluster, 1806-20, etc. However, these are hidden behind tens of magnitudes of visual extinction making them impossible for MACAO even if their K-magnitudes are now within the reach of VLTI. Other extremely interesting LBV's are in Carina, out of reach in October.

A very interesting object is Wray17-96 (2MASSJ17413543-3006389) originally thought to be the central star of a planetary nebulae, but now considered to be a very good LBV candidate (Egan et al., 2002). While not much is known about its variability, the spectrum and the luminosity of WRA17-96 resemble very closely the Pistol star which led Egan et al. to classify it as an LBV. The star is hidden by about 9 magnitudes of visual extinction, but still it has a K-band magnitude of K=4.8 and H=5.5, so even accounting for variability by one magnitude, it is still easily within the reach of VLTI in HR mode. the R magnitude is 12.6 and the V magnitude is about 15 (only B and R have been measured), so there should be no problems for MACAO either.

As most LBV's, Wra17-96 has a rich emission-line spectrum and is surrounded by a dust nebula. Contrary to other LBV's however, the nebula does not seem to be bipolar, but instead looks fairly round. In fact it was this ring nebula that first call the attention of observers to this star. At a distance of about 4.5kpc (Egan et al 2002), Wra17-96 is twice as far as η Carina, but still well within the reach of the VLTI with the UT's offered for science verification. All and all, therefore, Wra17-96 may well be the second LBV to be observed with VLTI.

The scientific aim of this project is in many respects similar to the investigation of η Carinae by Weigelt et al. (2007), with the important exception that, at least at the present stage, we will not be probing the object for binarity. By observing in high resolution in the region of the Brγ and HeI lines, we will investigate the geometry of the object in the expanding pseudo-photosphere (continuum) and the outer wind regions at 5-10 stellar radii. The HR mode of AMBER with a spectral resolution of $R = 12000$ or 25 $\mathrm{km\,s^{-1}}$ in K-band is required to resolve the features of the wind line profiles dominated by an expected terminal velocity is of the order of few hundred $\mathrm{km\,s^{-1}}$. A comparison with the detailed observations of η Carinae will allow us to determine whether Wra17-96 is a bona-fide LBV or some other type of massive star. As mentioned above, if the star is an LBV, it is important to establish whether it is rotating, and how fast. This will be determined by establishing the geometry of the wind and looking for asymmetries either as done by van Boekel et al (2003) using VINCI and 2 siderostats, or as done by Weigelt et al. (2007) using closure phases. And as it has become standard in the (LBV) field, the analysis of the observations will be done on the basis of comparison with the detailed NLTE models of Hillier et al. (2006 and references therein).

REFERENCES • Dwarkadas & Owocki (2002), ApJ, 581,1337 • Egan et al., (2002), ApJ, 572, 288. • Groh, Hillier, & Daminelli, (2006), ApJ, 638, L33. • Langer et al.,(1999) ApJ, 520, L49 • van Boekel et al., (2003). A&A, 410, L37. • Weigelt et al., (2007), A&A, 464, 87.

Calibration strategy:

HR observations with good S/N and good calibrations are ideally suited for this project. Thus, we will adopt the cal-star-cal procedure by observing a calibrator both before and after the observations. Phase closures are indispensible to study the stellar wind asymmetries.

Targets and number of visibility measurements

Target	RA	DEC	V mag	H mag	K mag	Size (mas)	Vis.	Mode	# of Vis.
Wra17-96	17 41 35.43	-30 06 38.9	15	4.8	5.5	2mas	—	HR 2.17	2
Wra17-96	17 41 35.43	-30 06 38.9	15	4.8	5.5	2mas	—	HR 2.056	2
HD166295	18 11 05.22	- 25 45 44.31	—	2.7	—	1.27	0.90	HR 2.17	1
HD166295	18 11 05.22	- 25 45 44.31	—	2.7	—	1.27	0.90	HR 2.056	1

Time Justification:

Fits to the Hillier model require as many visibilities as possible. However, the object is only observable at the beginning of the night, and the visibility does not change dramatically in the 4 hours that the object is observable. Therefore, if possible, we request two measurements, one as close as possible to the meridian, and the second as far as possible.