An interferometric view of binary stars

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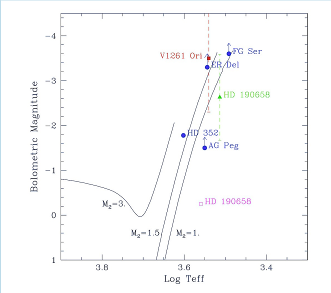
INTRODUCTION

Stars tend to form and live in binaries, with the fraction of binary stars being about 50% for solar-like stars to more than 70% for OB stars. A significant fraction of these binary stars will interact in one way or another during their evolution. Mass transfer will affect the chemical composition of the companion, which can for example become polluted in processed elements like in Algols or in Barium stars. It also leads to a mass increase of the companion, with sometimes strong consequences, such as blue straggler stars or Type Ia supernovae. Finally, mass transfer has an impact on the evolution of the orbital separation. The study of binary stars is therefore critical to apprehend many of the most interesting classes of stars. Moreover, the study of stars in binary systems is often our only means of constraining stellar properties, such as masses and radii.
A great fraction of the most interesting binaries are so compact that they can be apprehended by high-resolution techniques only, in particular by interferometry. Here are some examples of how interferometry allowed us to get important results on different classes of stars.

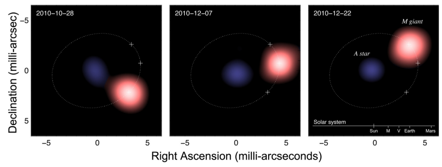
SYMBIOTIC STARS

Using interferometry, we precisely measure the diameters of several symbiotic and related stars. These diameters – in the range of 0.6–2.3 milli-arcsec – are used to assess the filling factor of the Roche lobe of the mass-losing giants and provide indications on the nature of the ongoing mass transfer. We can also use this information to put the stars in an H-R diagram. The main limitation in our conclusions is the poorly known distances of the objects (see refs. [3] and [4]).



Star	Parallax (mas)	$T_{\rm eff}$ (K)	Radius ($R_\odot$)	$M_{\rm bol}$	$f = R/R_L$	$v \sin i$ km/s	synchronised?
HD 190658	2.6:	3260	104:	–2.6:	0.4–1	?	–
HD 352	3.58	4000	44.7	–1.78	0.8–1	22	y
V1261 Ori	~ 1.96	3650	~ 120	–3.5	~0.3	< 4	n
ER Del	> 0.4	3500	> 115	< –3.3	0.2 – 0.3	< 4	–
FG Ser	< 0.6	3100	~ 160	< –3.6	~ 1	9.8	y
AG Peg	< 1	3550	> 47	< –1.5	0.25–0.55	8.5	y

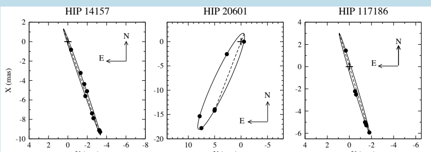
We also studied the symbiotic star SS Leporis and determined its orbit. We find that the M giant does not *stricto sensus* fill its Roche lobe. The mass transfer is more likely to occur through the accretion of an important part of the giant wind, which is enhanced compared to normal stars. See ref. [5].



PRECISE STELLAR MASSES

In anticipation of the *Gaia* astrometric mission, a sample of double-lined spectroscopic binaries is being observed with the aim to obtain the masses of the components with relative errors as small as 1 %.
In order to validate the masses derived from Gaia, interferometric observations are obtained for three SB2s in our sample with F-K components.

The masses of the six stellar components are derived. We note that almost all the derived masses are a few percent larger than the expectations from the standard spectral-type-mass calibration and mass-luminosity relation. Our calculation also leads to accurate parallaxes for the three binaries, and the Hipparcos parallaxes are confirmed. See refs. [1] and [2].

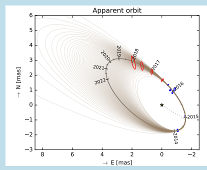


	HIP 14157	HIP 20601	HIP 117186
$\mathcal{M}_1$ ($\mathcal{M}_\odot$)	0.982 $\pm$ 0.010	0.9808 $\pm$ 0.0040	1.686 $\pm$ 0.021
$\mathcal{M}_2$ ($\mathcal{M}_\odot$)	0.8819 $\pm$ 0.0089	0.7269 $\pm$ 0.0019	1.390 $\pm$ 0.034

The visual orbits of the three SB2 observed with PIONIER. The node line is in dashes, while the position of the primary is indicated by the cross. The derived masses are indicated below each panel.

THE LBV HR CAR

Luminous Blue Variables (LBVs) are massive stars caught in a post-main sequence phase, during which they are losing a significant amount of mass. Interferometric observations spanning two years clearly reveal that the LBV HR Car is a binary star. It is not yet possible to constrain fully the orbit, and the orbital period may lie between a few years and several hundred years. Most importantly, we constrain the total masses of both components, with the most likely range being 33.6 $M_\odot$ and 45 $M_\odot$. Our results show that the LBV HR Car is possibly an η Car analog binary system with smaller masses, with variable components, and further monitoring of this object is definitively called for (see ref. [6]).



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