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COMBINED SPECTROSCOPIC AND INTERFEROMETRIC (NPOI) OBSERVATIONS OF THE Be STAR o CASSIOPEIAE

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RESUMEN

El análisis de las velocidades radiales de la estrella o Cas de los espectros tomados entre 1992 y 2008 en *Ondřejov* y *Dominion Astrophysical Observatory* nos permitieron reconfirmar la naturaleza binaria de este objeto, primeramente sugerida por Abt & Levy en 1978, y más tarde refutada por varios autores. Los parámetros orbitales de este sistema SB1 implican una función de masa muy alta de alrededor de una masa solar. Esto implica una masa muy alta de la estrella secundaria, posiblemente mayor que la de la estrella primaria. Para comprobar si hay la existencia de una secundaria tan masiva, o Cas fue observada con el interferómetro óptico de prototipo de la marina, el cuál permitió resolver espacialmente por primera vez ambas componentes binarias. Las observaciones interferométricas condujeron a la detección de una secundaria, cerca de 3 magnitudes más débil que la primaria. Se discuten las posibles características de este sistema binario peculiar.

ABSTRACT

The analysis of radial velocities of the Be star o Cas from spectra taken between 1992 and 2008 at Ondřejov and Dominion Astrophysical Observatories allowed us to reconfirm the binary nature of this object, first suggested by Abt and Levy in 1978, but later refuted by several authors. The orbital parameters of this SB1 system imply a very high mass function of about one solar mass. This in turn leads to a very high mass of the secondary, possibly higher than that of the primary. In order to check for the existence of such a massive secondary, o Cas was observed with the Navy Prototype Optical Interferometer, which allowed the binary components to be spatially resolved for the first time. The interferometric observations lead to the detection of a secondary, about 3 mag fainter than the primary. The possible properties of this peculiar binary system are discussed.

Key Words: astrometry — binaries: spectroscopic — stars: emission-line, Be

1. GENERAL

o Cas (HD 4180, HR 193) is a bright Be star (V=4^{m}.3–4^{m}.6 var., $B-V=-0^{m}.03$, $U-B=-0^{m}.59$, B5IIIe, $v \sin i = 220$ km s^{-1}). *o* Cas is a typical Be star which shows: (i) long-term changes from absorption to emission in Hα line and back (Peton 1971; Hubert-Delplace & Hubert 1979), (ii) correlation between star brightness and strength of Hα emission (Koubský et al., in preparation), (iii) variations of radial velocity (Abt & Levy 1978; Koubský et al. 2004), and (iv) short-term photometric variability (Hubert & Floquet 1998).

2. RADIAL-VELOCITY VARIATIONS: BINARY OR LONG-TERM CHANGES?

Using He I absorption RVs from 20 photographic spectra, Abt & Levy (1978) – (AL) proposed that o Cas is a single-line spectroscopic binary with an orbital period of 1033 days. Harmanec (1987) showed that available RVs could be folded with various periods and suggested that the star should not be considered a spectroscopic binary. He suspected that the RV curve derived by AL was a manifestation of long-term variations known for number of other Be stars. Koubský et al. (2004) secured more spectra of o Cas with better S/N and showed that the RV variations were *indeed* due to orbital motion, but were unable to explain why the lines of the secondary, probably more massive than the primary, were unseen.

3. RESULTS FROM SPECTROSCOPY, PHOTOMETRY AND INTERFEROMETRY

Here we report results of our o Cas study which started in 2004. We collected about 400 high S/N

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TABLE 1

ELEMENTS OF o CAS FROM SPECTROSCOPY AND INTERFEROMETRY

Element	Solution
P (d)	1031.03 ± 0.70
$T_{\mathrm{RV\,max}}$	51760.5 ± 1.4
$K(\mathrm{km\,s^{-1}})$	21.597 ± 0.068
rms ($\mathrm{km\,s^{-1}}$)	0.940 (one measurement)
a(mas)	17.1
$\Omega(°)$	274.5
$i(°)$	115
e	0
$F(m)$ ($M_\odot$)	1.076

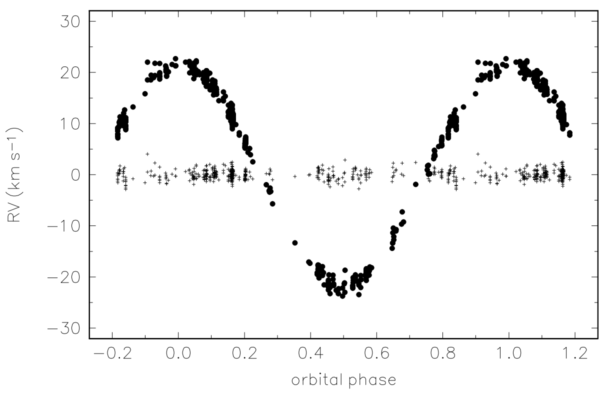

Fig. 1. A phase diagram for the 1031-d period.The RV's were measured on the steep wings of the Hα emission line and prewhitened for the long-term changes. The O-C deviations are plotted as small crosses.

spectra, measured them for radial velocity, and derived new elements using the code FOTEL (Hadrava 2004). The elements are in the upper part of Table 1, while the phase diagram is in Figure 1. From the compiled measurements of Hα emission strength and UBV photometry we concluded that the correlation luminosity/strength of Hα emission suggests (according to Harmanec 1983) that the envelope is seen under a low angle.

Definitive proof of the duplicity of o Cas came from observations with the Navy Prototype Optical Interferometer (NPOI), which resolved two components in the visual with a magnitude difference of $\Delta m_V = 2.9$ mag. Orbital motion consistent with the spectroscopic period of 1031 d was subsequently de-

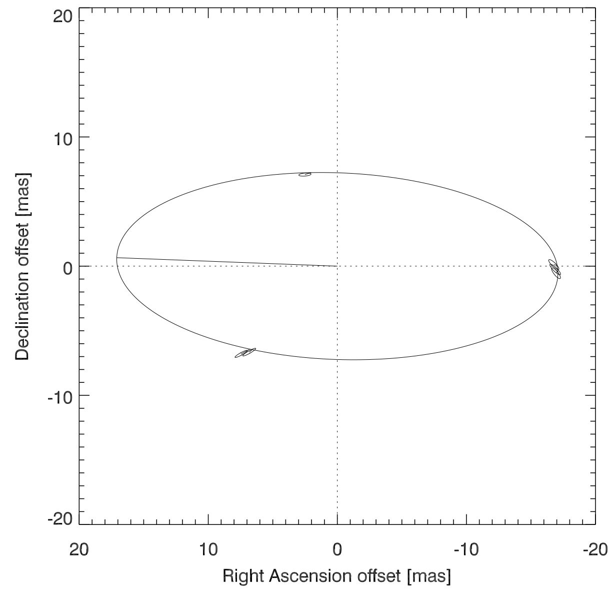

Fig. 2. Visual orbit of o Cas. Note that the NPOI results suggest that the inclination angle between the normal to the orbital plane and the line-of-sight is much higher than the suspected inclination of the envelope.

tected by NPOI, and a preliminary orbit fitted to the relative astrometry and the RV curve is shown in Figure 2, adopting an orbital eccentricity of zero. These results are consistent with the elements describing the motion of the photo-center determined by Jancart et al. (2005) from Hipparcos data.

NPOI observations also detected a drop of the visibility in a channel centered on the Hα line. This is interpreted as an extended line emission component, with a Gaussian width of 1.8 mas. The shape is roughly circular.

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