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# VLBA ASTROMETRY OF THE AeBe STAR EC 95 IN SERPENS

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RESUMEN

Presentamos un análisis de once observaciones VLBA del sistema binario EC 95 obtenidas a lo largo de 2.5 años. Cada una de las dos fuentes fue detectada un número suficiente de veces para permitir ajustes astrométricos independientes de alta calidad. La paralaje trigonométrica deducida de estos ajustes coresponde a una distancia $d = 429 \pm 2$ pc. Nuestras observaciones también sugieren que ambos componentes de EC 95 podrían ser estrellas jóvenes de masa intermedia.

ABSTRACT

We present an analysis of eleven VLBA observation of the binary system EC 95 covering a total observing time span of 2.5 years. Both sources in the system were detected a sufficient number of times to allow for high quality independent astrometric fits. The trigonometric parallax obtained from these fits corresponds to a distance $d = 429 \pm 2$ pc. Our observations further suggest that both components in EC 95 could be young stellar objects of intermediate mass.

*Key Words:* astrometry — binaries: general — magnetic fields — radiation mechanisms: non-thermal — radio continuum: stars — techniques: interferometric



## 1. INTRODUCTION

Several years ago, we initiated a large VLBA project aimed at measuring the trigonometric parallax of several young stars located in the most often studied star-forming regions within a few hundred parsecs of the Sun. As part of this program, we observed the highly embedded ($A_V = 36$, Preibisch 1999) young stellar object EC 95 toward the Serpens molecular core at a distance of about 415 pc (Dzib et al. 2010). EC 95 is presumably the precursor of a 3–5 $M_\odot$ Herbig AeBe star (Preibish 1999; Dzib et al. 2010).

An unexpected outcome of these observations was the demonstration that EC 95 is in fact a tight binary system (see Figure 1) as discussed in Dzib et al. (2010). Here, we present new VLBA observations of EC 95 which provide additional constraints on the distance to the source, and the nature of the stars in the system. The data will be described in § 2, and analyzed in § 3. Conclusions and perspectives are given in § 4.

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## 2. OBSERVATIONS

In addition to the eight observations reported by Dzib et al. (2010), we will make use here of three VLBA observations collected between March 2010 and September 2010. In total, our eleven observation cover a time span of 2.5 years. The data were edited and calibrated using the Astronomical Image Processing System (AIPS). All data (including those presented in Dzib et al. 2010 were reprocessed). Each epoch consisted of intertwined observations of the target, a main phase calibration, three secondary calibrators, and all sky calibrators. The calibration followed standard VLBA procedure for phase-referenced observations, including the multi-calibrator schemes and, tropospheric and clock corrections. These calibrations were described in detail by Loinard et al. (2007), Torres et al. (2007) and Dzib et al. (2010). After the calibration, the visibilities were imaged with a pixel size of 50 $\mu$m as using a weighting scheme intermediate between natural and uniform (ROBUST=0 in AIPS). The rms noise levels in the final images were 0.08–0.12 mJy beam$^{-1}$.

## 3. RESULTS

From our observations, the primary of the system (EC 95a) was detected 5 times, while the secondary (EC 95b) was detected 9 times. The absolute coordinates of each component was measured accurately from these observations, and an astrometric fitting scheme including acceleration terms

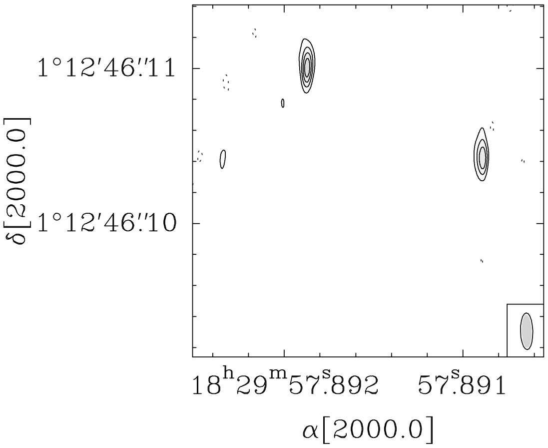


Fig. 1. VLBA image of the EC 95 system on November 29th, 2008. The contour levels are −3, 3, 6, 9, and 12 times 80 $\mu$Jy beam$^{-1}$, the rms noise of the image. Data from Dzib et al. (2010).

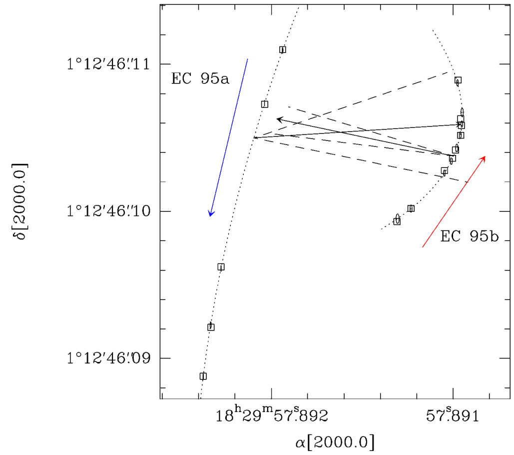


Fig. 2. The positions of EC 95a and EC 95b after removing the parallactic components. The black arrows represents the acceleration of each component from their mean epoch. The blue and red arrow, show the direction of the movement of EC 95a and EC 95b, respectively.

(described in detail in Loinard et al. 2007) was used to calculate the astrometric elements of each component separately. The reference epoch was taken at the mean of the detection for each component: JD 2455078.63≡2009.30 for EC 95a, and JD 2454765.98≡J2008.90 for EC 95b. The best astrometric elements are:

For EC 95a,

$$\begin{aligned}
\alpha_{J2009.3} &= 18^{\rm h}29^{\rm m}57.^{\rm s}892097 \pm 0.000001 \\
\delta_{J2009.3} &= 1^\circ12'46.''10495 \pm 0.00015 \\
\mu_\alpha \cos\delta &= 5.27 \pm 0.03 \text{ mas yr}^{-1} \\
\mu_\delta &= -14.62 \pm 0.33 \text{ mas yr}^{-1} \\
a_\alpha \cos\delta &= -2.76 \pm 0.05 \text{ mas yr}^{-2} \\
a_\delta &= 0.15 \pm 0.62 \text{ mas yr}^{-2} \\
\pi &= 2.33 \pm 0.02 \text{ mas}
\end{aligned}$$

and for EC 95b,

$$\begin{aligned}
\alpha_{J2008.9} &= 18^{\rm h}29^{\rm m}57.^{\rm s}890998 \pm 0.000003 \\
\delta_{J2008.9} &= 1^\circ12'46.''10374 \pm 0.00011 \\
\mu_\alpha \cos\delta &= 1.83 \pm 0.04 \text{ mas yr}^{-1} \\
\mu_\delta &= -3.42 \pm 0.10 \text{ mas yr}^{-1} \\
a_\alpha \cos\delta &= 2.36 \pm 0.06 \text{ mas yr}^{-2} \\
a_\delta &= 0.41 \pm 0.17 \text{ mas yr}^{-2} \\
\pi &= 2.32 \pm 0.05 \text{ mas}
\end{aligned}$$

The corresponding distances are $428.9 \pm 2.2$ pc, and $429.7 \pm 8.7$ pc, respectively. Both results are in agreement with a distance $d = 429 \pm 2$ pc for the EC 95 system. This is slightly larger than the distance of $414 \pm 5$ pc reported in Dzib et al. (2010). The difference is largely the result of a slightly different data calibration scheme, and of the larger number of data points included here.

## 4. DISCUSSION AND CONCLUSIONS

The distance to EC 95 obtained here is $429 \pm 2$ pc rather than $414 \pm 5$ pc, as previously reported. The change is only about 4%, so the conclusions presented by Dzib et al. (2010) are not significantly affected. An interesting result from this new analysis, however, concerns the accelerations. Within the errors, the acceleration of EC 95a and EC 95b appear to be directed in opposite directions (as they should for a Keplerian system) and have similar magnitudes. This suggests that the two components are of similar masses, and might both be intermediate mass protostars. This results needs to be confirmed by additional observations which we expect to perform in the coming years. From the data presented here, one can estimate an orbital period for the system of about 10 years, so the required data should be collected regularly over the coming 5 to 10 years.

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